ELECTRICAL ENGINEERING

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The Cover: The Ohio State University radio telescope antenna consists of an array of 96 helices mounted on a pivoted steel ground plane 160 feet long by 22 feet wide. Ohio State University Photography Department photo

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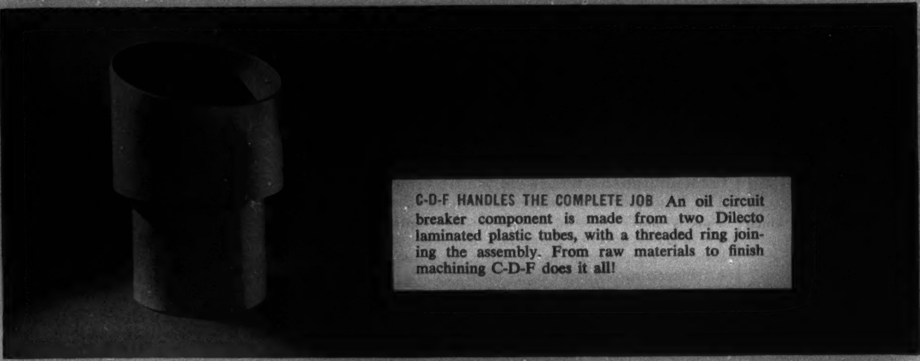
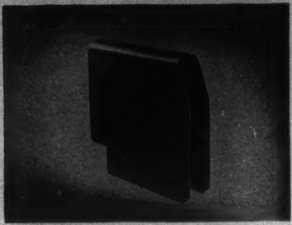


C-D-F HANDLES THE COMPLETE JOB An oil circuit breaker component is made from two Dilecto laminated plastic tubes, with a threaded ring joining the assembly. From raw materials to finish machining C-D-F does it all!

C-D-F KNOWS HOW TO MACHINE PLASTICS. A bus bar gets a covering of molded Dilecto over copper supplied by the customer. The plastic ends are skillfully trimmed on a smooth saw.

C-D-F MOLDS MANY SPECIALTIES. This shaft insulator for a circuit breaker is molded from C-D-F's cloth-based industrial thermosetting plastic, Celoron. Note complexity of mold, clean detailing.



C-D-F USES MODERN METHODS. Large quantities of arc chute barriers are made from paper-based Dilecto. Operations include pressing, cutting, post-forming and trimming.

Dependable equipment relies on C-D-F insulation!

C-D-F OFFERS UNIQUE MATERIALS. This contact shaft for an air circuit breaker is another example of molded C-D-F Celoron used in switchgear because of its high impact strength.

C-D-F IS A SKILLFUL ASSEMBLER. Made from Grade C rolled Dilecto tubing, these pots are turned, bored, slotted. Then a macerated plastic end is inserted and arc resistant varnish finish applied.

C-D-F UNDERSTANDS THE ELECTRICAL INDUSTRY'S NEEDS. Precisely machined to close tolerances, Dilecto panel boards guarantee dependable insulation, help designers save space.

See our catalog in Sweet's Design File for basic product data and sales offices. Write for detailed information, or send us your print for quotation.

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HIGHLIGHTS........

Automation in the Process Industries. Continuous automatic production, or automation as it is interpreted today, has not constituted a second industrial revolution. Rather, it is evolutionary in nature, a series of steps towards the advancement of electrical living—which means a more abundant life for America (*pp. 371–3*).

Processing Air-Traffic-Control Information Electronically. A digital information-processing system has been built for handling and storing flight plans and weather information automatically over Teletype lines. The system can be connected to similar systems by a Teletype network with automatic switching facilities (*pp. 374–7*).

Communication—Where Do We Go From Here? The need for a huge project to code the mounting volume of human knowledge and make it available promptly and accurately is stressed. Various developments in the near future are suggested. Through continued improvements in communication, and the gradual disappearance of obstacles to its full use, should come peace and wisdom if the world can survive its present crisis (*pp. 367–70*).

Application of Germanium Power Rectifiers. Competitive in first cost, this germanium power rectifier has the advantage of high efficiency, easy installation, quietness of operation, and little maintenance (*pp. 418–22*).

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An Electronic Blood-Count Meter. This instrument determines the average volume of solution per single particle, which is the reciprocal of concentration. The optics consist of an ordinary microscope, while the electronics require only common inexpensive components (*pp. 388–91*).

Variable-Reactance-Type Dimming Control for Fluorescent Lamps. This new dimming system is discussed in terms of circuit requirements, a description of the circuit, the range of dimming, starting requirements, stroboscopic effects, wiring and control, and its many applications (*pp. 378–82*).

Grounding, Bonding, and Lightning Protection in Oil Refineries and Chemical Plants. A brief review of the various aspects of grounding practices in both industries is presented. However, the primary emphasis is put upon the situations most commonly encountered and procedures designed to protect personnel, equipment, and plant (*pp. 400–03*).

Electric Equipment for Aluminum Anodizing. Most large anodizing installations are best suited to the use of synchronous-motor-driven shunt-wound-generator power supply with automatic process control. Small installations are better suited for manually controlled dry-disk rectifiers (*pp. 384–7*).

Recommendations of IEC Technical Committee 24 on Electric and Magnetic Magnitudes and Units. These recommendations are discussed in terms of the sign of reactive power; the name for mks or Giorgi system; the assignment of names "Magnetic Polarization," "Intrinsic Induction," and "Magnetization"; the name for the unit of magnetic induction in the Giorgi system; rationalization of the electromagnetic field equations; the relation of the ampere turn per meter to the oersted; revision of definitions in the International Electrotechnical Vocabulary; the comparison of 3- and 4-dimension systems; and preparation of a document with all TC 24 decisions since the founding of the IEC (*pp. 406–08*).

A New Look in Lamp Bases. This article gives a discussion of the data and tests on aluminum as it performs as a base-making material, when it is used instead of brass. The two primary problems have been concerned with whether aluminum could be adapted to the manufacturing methods, and whether it would perform satisfactorily in service (*p. 414*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

The Electrical Flare of the 1740's. This decade saw remarkable discoveries which provided a dynamic prologue to the future progress. The period is treated with reference to the preceding knowledge, how the flare was sparked, a discussion of the condenser, and the general level of attainment (*pp. 392–7*).

Ignitron Multiple-Unit Cars. This first quantity application of ignitron rectifiers on multiple-unit cars is discussed in terms of service operations, performance, control system, rectifier d-c supply, traction motors, main circuit and protective apparatus, auxiliary circuits, carbon brush life, inspection periods, power consumption, and conclusions (*pp. 408–13*).

Coaxial Cavity Filters for Multiplexing of 900-Mc Radio-Relay Systems. Filters acting as multiplexers, diplexers, and multidiplexers have been developed to provide for simultaneous application to one antenna of two or more radio transmitters and receivers operating in the 900-mc range. Such equipment is used in a recently developed radio system (*pp. 425–9*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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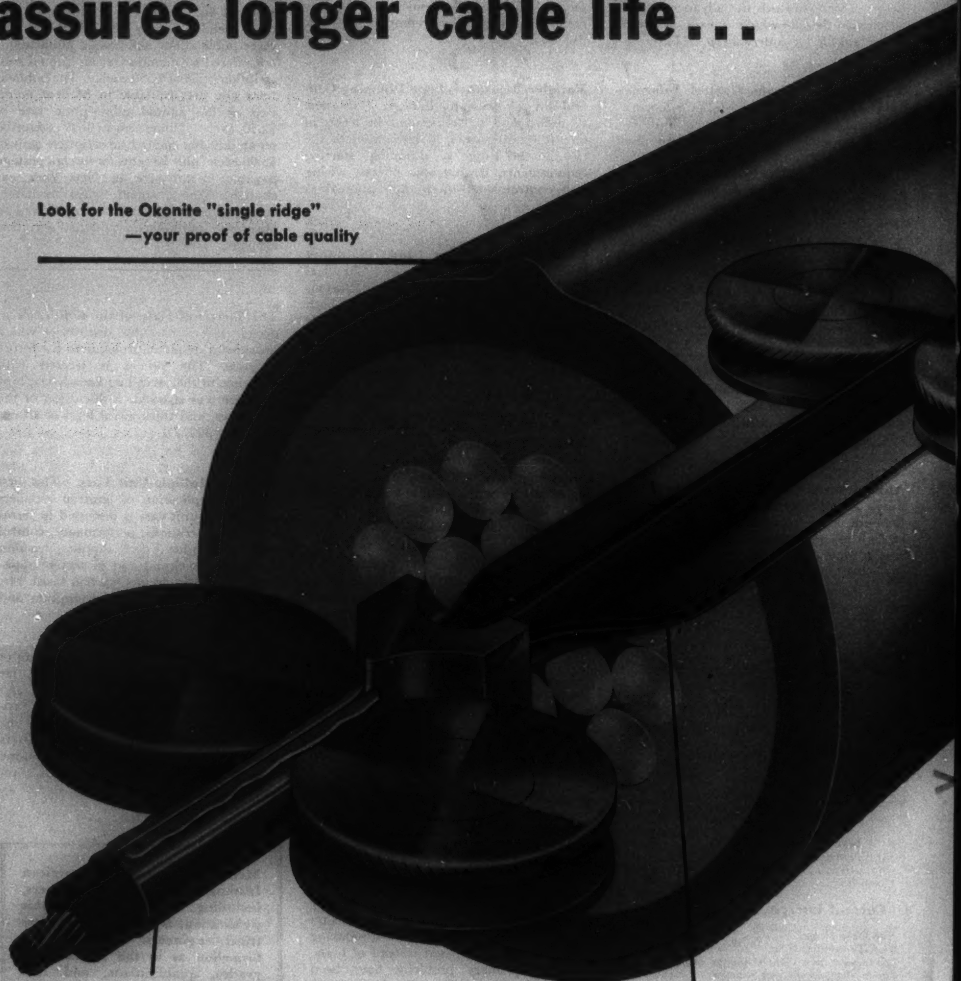
Why the strip-insulating process assures longer cable life...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strip with tin backing

COMMUNICATION

Where Do We Go From Here?

VANNEVAR BUSH
HONORARY MEMBER AIEE

The diverse and complex means of communication are classified and, based on this classification, an effort is made to see what lies ahead. Although the present international situation is tense, in the long run the maintenance of peace depends chiefly on communication between peoples and its uncoerced functioning. Thus anyone working to improve communication methods is laboring to benefit his fellow man.

IT is customary in reviewing the entire subject of communication to start with the Greeks. I should prefer, however, to go back to a somewhat earlier period when the first prosimian, or whatever our ancestor may have been, climbed down out of the trees, began to use tools, and most notably began to apply his curiosity with practical effect. For many reasons he became the progenitor of the dominant race, but one powerful reason was that he learned to communicate and to use symbols for the purpose. From that time an individual's struggle with his environment was based, not on his own limited experience alone, but on the far sounder basis of the experience of his fellows and his forebears. All that is called civilization resulted from the fact that man learned to record, transmit, and consult the record of his perceptions and his reasoning about their interrelationships. At first he did this roughly and inadequately with a small vocabulary. Later he turned to more and more elaborate means of communication.

A great step forward occurred when the invention of movable type brought low-cost printing, which in turn made possible mass education. Many reasons may explain why the West then spurted forward in material ways while the Orient lagged in spite of its continued excellence in some of the subtler aspects of art and philosophy. But one of those reasons undoubtedly was that the new printing technique was more adaptable to the western languages built from alphabets, and was hardly applicable at all to the ideographic languages of the East. I believe this unbalance in communicational facility may soon be overcome as new methods of printing are developed.

Today there are diverse and complex means for communication. You are not interested in having me recite a catalogue of them. Nor have I any intention of lifting your spirits with a rhapsody on the wonders of modern communication. In fact, I think some of those wonders are still rather crude. It may, nevertheless, be worth while to classify them and on the basis of their classification attempt to see, dimly, what lies ahead.

The simplest form of communication is between individuals, and the principal instruments—in addition to direct speech—are the telephone, the transmitted message, and the letter. We take just pride in our telephone system. With automatic dialing it has become highly flexible, fast, and reliable. Some people can now make calls all over the country merely by turning a dial; and more will soon be able to do so, without human intervention, and without human error except their own. It is possible, if desired, to talk comfortably, without becoming entangled in the cords and with both hands free. There is no reason why the person one is conversing with should not be seen, if people are willing to pay for the necessary channels; but such a luxury would hardly seem to be worth the cost.

The sounds heard over the telephone bear a surprisingly close resemblance to those of the human voice, close enough in fact to satisfy any reasonable demands. What else is there to do? Well, the telephone is still, on occasion, a nuisance, breaking in on our hours of rest, work, or contemplation in a most peremptory manner. There may be ways, aside from having competent secretaries, by which conversations could be carried on when both participants, rather than just one, want to talk and find it convenient to do so. Certainly there are more effective ways than those employed today of carrying on a conference of several persons. A great deal of the traveling done, just to talk to someone, does seem rather senseless, and it becomes more senseless as the people with whom we would talk are increasingly dispersed. The only difference between a conference around a table, and one over a telephone with the participants seated behind a number of separated desks, is the absence of gestures and facial expressions. There may be ways of supplying what is essential here, without unduly tying up television channels, which transmit a full

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Essentially full text of an address presented at the 75th anniversary meeting of The American Society of Mechanical Engineers, New York, N. Y., February 16, 1955.

Dr. Vannevar Bush is president, Carnegie Institution of Washington, Washington, D. C.

picture 30 times a second. Ninety per cent of what is transmitted in television is often sheer repetition, whereas for an effective conference one wishes merely to be able to see occasionally the facial expression of the speaker.

Billions of letters are being written. This process is still extremely crude. To write the letter an individual talks to a stenographer or a machine, and what has been said is reproduced, often none too precisely, by a girl who pushes keys on a typewriter. This process can be shortened by talking to a machine and mailing a disk or tape, to talk back on a distant machine, but this does not readily produce a convenient record. No doubt a machine could be made that would type what is spoken into it. It would do strange things to the language, perhaps, but it might be useful. Or the problem could be eased by writing fewer letters and telephoning more, if there were a convenient way of recording conversation so that the record could be filed and consulted, and if the aversion to having such records could be overcome, a system could be devised by which the recorders could be in use only when both parties wished them to be.

When a letter is mailed, a half dozen persons have to read the address and toss it into its appropriate compartment. This is utterly archaic. It is quite possible to read addresses photoelectrically, if they are in proper code, and to render all sorting automatic. The great bulk of the mail could be thus handled. Incidentally, before too long, everyone will have two addresses—one for mail and one for the telephone. It would be nice if these two addresses could be combined. I wish personally, that all bulk-mailed advertising had to carry a prominent distinctive mark. I should then have, at my house, two slots in the door, and I should ask the postman to drop the advertising in the second slot, which would lead straight to the cellar. I am sure he would gladly comply.

The second principal form of communication is from one to many, or from a small group to a large audience. It is usually unidirectional, although a heckler sometimes attacks a public speaker, especially when the latter is expounding political wisdom. The greatest instrumentation here is the printed word. Much progress is being made in printing. Metal type is on the way out, although it will take some time for it to disappear completely. We are approaching national newspapers, and magazines that are nearly current exert a profound influence on the public's understanding, or perhaps at times on its misunderstanding. Better methods of printing can confidently be expected as well as better methods of distributing what is printed.

Entertainment is a form of communication. I think that it is fortunate that entertainment and advertising have made possible the enormous growth of radio and television. Together with the press and magazines, these media are producing an informed electorate and a united public opinion throughout the country beyond anything that was possible without them. Of course there are and will be abuses so long as clever men try to sway multitudes for selfish purposes. But I suspect that a demagogue would have to be superhuman to put over a false act on the American people when he appears before them on their television screens at so close range that they can almost count the hairs in his eyebrows. I also suspect, although perhaps I am overoptimistic, that the very weight of advertising that is thrown at the public today is developing a healthy scepticism, and that this may in time necessitate a greater reliance on reason and less on mere repetition. Bacteria, when they are attacked by an antibiotic, sometimes mutate and escape its destructive effects. A public attacked by slogans may find some equivalent protection. But the subject here is means of communication rather than its effects.

Intermediate between the two great forms of communication mentioned is another, the transmitting of special messages or signals. I do not have in mind in this connection the telegraph message, although I think everyone would welcome a technical advance in this field which would make it possible to place on a man's desk a few words, more promptly, accurately, and at lower cost. The general idea of the teletypewriter might conceivably be extended to make this possible. I have in mind rather the transmission of messages where most of the data are already in the hands of a recipient, and all that needs to be sent is a signal or symbol to select or alert. Paul Revere and William Dawes were sent on their rides of warning by the hanging of a light in the now-fallen tower of Old North Church. The modern fire alarm system is a good deal more effective and yet leaves much to be desired. Fire losses today are enormous, and residential fires in particular cause great loss and suffering. Perhaps some of this loss might be avoided if our alarm system, however efficiently transmitted, did not depend so much on someone seeing smoke. A more dependable system would be one which automatically called the fire department whenever there was either undue smoke or excessive heat in any part of a house. It would have to be periodically tested, of course, and provision would have to be made to alert the family as well as the authorities. It is quite possible to build such a system, and there is not much doubt that it would pay. In fact there are systems which fulfill some of these requirements in operation now in certain public buildings, and extension to residences is almost straightforward from a technical standpoint.

Another type of communication of this general class is one that gives the location of things. The time is approaching when the position of every airplane in the sky will be known centrally at all times. It would be helpful to have a similar system for the control of freight shipments and trucks. The detail involved in such systems is of the kind that can be dealt with very effectively by modern data-handling devices. It is about time for someone to devise a good automatic system to signal when robbers hold up a bank or a store.

The progress of civilization in peace time depends, and has always depended, not only on current thoughts and findings, but on the skill and facility with which we create, store, interchange, consult, and utilize the whole record of collective past experiences. Enormous strides are being made in the development of methods for creating a record of what is learned—in printed words, by photography, or on a magnetic tape. Also, strides are being made in developing means for the transmission of ideas from one to another or from a central point to great audiences. But in one exceedingly important phase of the whole problem, little progress indeed is being made. This is the phase of finding in the record the information needed. If the record of experience is to serve well, it is necessary to be able to extract from it at will, promptly and inexpensively, any single item of current moment. This is of great importance for the progress of science, but it is also important in every professional field of activity and especially in engineering, which is daily becoming more complex in the ways in which it applies science economically to meet the needs and desires of mankind.

The record is being built at a prodigious rate. Books, magazines, technical journals, and reports are being produced by the ton. The Library of Congress reported in its *Quarterly Journal of Current Acquisitions* for August 1954 that in the fields of science, technology, medicine, and agriculture it received in the fiscal year 1953 approximately 30,000 journals, including 2,000 new titles; 25,000 research reports; 15,000 books and monographs; 15,000 manuscripts; 10,000 pamphlets; 5,000 prints, blueprints, microfilms, etc.; and 150,000 maps and charts.

Libraries are filled to overflowing and their growth is exponential. Yet in this vast and ever-increasing store of information particular items are still sought by horse and buggy methods. As a result there is much duplication and repetition of research. We are being smothered in our own product. While the work of thousands of able and devoted men, full of significance and timeliness to others, is recorded with great care, a large and increasing fraction of this work is, for all essential purposes, lost simply because it is not known how to find a pertinent item of information after it has become embedded in the mass.

The problem is not essentially one of techniques. It is rather one of deciding who is to do the job of clearing up the confusion and under what auspices. There are many good techniques available. Recently I participated in a study of how mechanization could be applied to the problem of searching in the Patent Office, where millions of items need to be scanned for equivalents of the combinations presented in patent applications. This study showed that there are at least 50 companies active in the production of one kind or another of data-handling equipment. I have not time to review all the ingenious devices now being used for commercial purposes by banks, insurance companies, and other businesses, or for scientific computation and analysis in hundreds of fields of research. Suffice it to say that there are several ways in which items can be scanned at the rate of 1,000 a second, selected in accordance with a complex code, and reproduced automatically. Photographic methods can reduce the size of a record by a factor of 100 to 1 or more, and re-enlarge on call with negligible loss of legibility, thus cramming the material of 1,000 books into the space of a cigarette package. Digital computing devices can manipulate records in the form of numbers at the rate of 1,000,000 operations a second if necessary. Magnetic tape can receive any kind of data, combine them, and reproduce them at will; and it lends itself to ready erasure, replacement, and rearrangement. There is no lack of powerful, versatile equipment, which is quite capable of rendering our stored records available in prompt, accurate, effective fashion, and at a distance if this is desired.

But to code the scientific literature or legal documents or any other part of the mounting records and thus to place them under the control of machinery responsive to our will is a stupendous undertaking. Worse than that, it is everyone's business and the assigned responsibility of no one group in particular. There is not the slightest doubt that it would pay, in a very practical sense, to do the job no matter how seemingly great the cost. It would pay everyone, and the expense should therefore be borne by everyone. Thus it is a task for government. But is it possible for a government which cannot even mechanize its postal system to be farsighted and courageous enough to undertake a task of such complexity and such magnitude? Probably not. The methods to be adopted, moreover, are not at all clear at the moment. The whole art of data handling is improving every day, and it would be a mistake to freeze upon a single system prematurely. So it probably would not be wise to plunge in at once and undertake a comprehensive and expensive program for, to use an example, the entire bulk of scientific literature. The various possible approaches need rather to be tried out on a more modest scale. The time has most certainly arrived when special sections of the record can be subjected to mechanization with genuine benefit to those who use them.

Looking forward, I am confident that there will be further advances, most interesting ones, through the whole range of devices by which man communicates with his fellows. As a result I believe the human race, if it does not commit suicide by indulging in total war, will advance in knowledge and understanding and perhaps also in wisdom. I believe there will be advances in our mastery over the records created, rendering them easier to consult by means which would now seem strange and bizarre which will make obsolete much of what is now done, but which will give a new power and freedom to the creative mind and thereby open the way for another spurt forward of civilization. For civilization advances only as it acquires new experience and only as it makes its experience available and useful.

Communication is the lifeblood of democracy. An informed and intelligent electorate is our bulwark against political chaos. Education of the people is dependent on the means of communication that are available. In its simplest form, a teacher talking to a group of pupils, communication is an essential element. But in the more complicated processes by which the citizens of a democracy become informed, the problem of communication is more involved and extensive. Today there are intricate and powerful means for the interchange of thought among the entire population. On the skill and wisdom with which these means are employed depend the stability and prosperity of our republic.

Even more depends upon the progress in this regard. The fate of our civilization today depends on whether all-out war can be avoided. In these perilous days, when the threat of mass destruction hangs over us, we wish with all our hearts for peace; we would, if we could, put an end to all war. For the moment, in the maelstrom of international affairs as they exist, we are utterly dependent, for the attainment of peace, on the enhancement of our military strength and on our determined and steady diplomacy in meeting current crises. We have recently met one and done it well. But in the long run the maintenance of peace depends chiefly on communication between peoples and its effective uncoerced functioning. There is no people on earth that would wish to go to war if it understood the appalling consequences of such an act. No country can ever again win a great war in the sense of advancing its national interests by conquest; any war that used the thermonuclear bomb, or one of the many other possible terrifying weapons, could result only in disaster to both participants, setting the clock of civilization back perhaps 1,000 years and delivering the world again to barbarism and pestilence. If the peoples of the world know this, and if the people control, there will be no great wars. I know that democracies or nationalistic powers embodying some of the democratic spirit have gone to war with one another in the past. But no people, in control of their own affairs, and with full knowledge of the power of modern weapons, will commit suicide. All attempts by demagogues to lead a nation to conquest will fail if the people really understand. And this is a matter of communication.

Today peoples are not everywhere in control, and they do not always understand. Behind an iron curtain they are fed on lies and propaganda by a tightly organized minority, which follows the path of imperial Russia and aims to conquer the world, by war when necessary, but preferably and more effectively by intrigue, penetration, and subversion. In a world where great sections of the population will not be ready for democracy in a generation, this aggressive minority has found devilish methods of bringing all people under its sway.

This threat must be met with realism, patience, courage, and steadfastness. We are doing well, in the United States, to keep our balance under stress. True, we have not been perfect; we have erred at times, and we have often been misunderstood or mistrusted by our friends. But, as a nation, we are solidly behind the government's program as it stands in foreign relations. We shall arm, and in every phase of modern weapons we shall develop strength. We will have nothing to do with preventive war; nor shall we attack even if the provocation is acute. But we will, in our strength, halt the advance of Communist forces before they engulf all the hesitant peoples of the earth and leave us standing alone in a hostile world.

This is for the immediate present. For the long pull we would use every means to spread understanding among men. We cannot now penetrate the iron curtain well, but times will change. There looms ahead of us a long period of military stalemate, during which all-out war is not likely to erupt except by accident or from desperation. There may be minor wars, and there will be international contests waged by strange means falling just short of open war. There will be a period of dangerous stress, when we shall need all our resolution to maintain our sanity, to preserve our free institutions, and to avoid succumbing by imitation to the very tyranny we fear. It can end in different ways, possibly in total disaster but possibly too, in a world from which war is banished and the primary causes of war forever removed.

Our hope rests on the gradual spread of knowledge among men, and on the assumption that with knowledge will come true wisdom. In this hope we depend on the improvement of means of communication and the gradual disappearance of obstacles to their full employment. Thus the subject of our thinking is one of crucial importance. It is one on which the progress of civilization has always rested, and on which it will rest more heavily in the years to come. Any man who works to extend the power and versatility of methods and machines by which one man communicates with another, any man who struggles to bring new ways of communicating into uninhibited effect, can do so with a full conviction that he is laboring for the benefit of his fellow man.

"Armor" for Magnets

New 400-ton die-casting machine, in the Edmore, Mich., permanent-magnet plant of Carboloy Department, General Electric Company, casts aluminum sheathes on large magnets such as those used in radar installations. Magnet "insert" shown weighs about ten times more than the aluminum. In casting the 1/4-inch-thick aluminum casing at 2,000 psi around the magnets, no special methods are used as the "pull" of the premagnetized magnets automatically hold them against the 2-piece cavity die, shaped to the magnets' contour. The finished work is ejected from the machine at 3,000 psi. Magnets are encased in aluminum for insulation and to simplify installation.

The Engineer and Automation in the Process Industries

EVERETT S. LEE
FELLOW AIEE

The word "automation" has become one of the most overused, and probably misused, words in our modern vocabulary. To the electrical engineer, however, it means the advancement of electrical living as we progress from manual methods to mechanization, and thence to automation. To America as a whole it means more goods for more people at less cost.

AUTOMATION has become a magic word. One reads about it in the engineering papers, in the trade press, and in the news of the day. It is blamed as the reason for the world's ills and credited as the source of its joys. It is reminiscent of a story about a bishop who, when asked to speak on "War, Peace, and the Human Race," asked that his subject be changed to read: "The Moon, Stars, and Life Eternal."

To the engineer automation is an evolution in manufacturing operations from manual operation to mechanization, and thence to automation. He has been involved in this evolution for many years.

In the manual area of unit production an operation is performed by the use of hands or of hand tools; and the hand tools were developed, designed, and guided in manufacture by the engineer.

In the mechanization area of mass production, manually operated power-driven machines, with varying degrees of controls, are used to perform one or more operations. Here the labor force has already been substantially upgraded, for skilled specialists are required to operate and maintain many of these machines. It was the engineer who developed the machines, designed them, guided their production, and integrated them into the mass-production line.

In the automation area of continuous automatic production, automatic machines are integrated with transfer devices to perform a series of continuous automatic operations. Here, there is practically no physical effort left in the content of the average job, and the man on the production line has been trained and upgraded to become the skilled machine specialist or maintenance expert. Here, again, it is the engineer who has developed the machines, designed them, and guided their production, and who will integrate them into the continuous automatic production line. The development engineer, the design engineer, the application engineer, the process engineer, the manufacturing engineer—all have contributed to these advances.

PRODUCTS OF AUTOMATION

THUS, this automation that is being talked about is of the engineer, by the engineer, and with the engineer working closely with the manager to bring into being all the products which have brought enjoyment and health and abundant living to the American people. Without these production processes as they are known today, these things would not be possible.

The population of the United States increased 22 per cent between 1939 and 1953, and in the same period the number of jobs went up 35 per cent. But in the field of manufacturing where automation has advanced most rapidly, Federal Census figures show that employment increased 73 per cent during these same years. If technology in the automotive field had stopped in 1908, it has been calculated that it would cost $65,000 to build a present-day car at today's wages.[1]

The mechanization of industry has reduced costs, has increased output, and has increased employment. It has given more goods to more people at less cost. It has brought the United States into world leadership, where the recital of the things this nation has is an amazement.

The average American family today, on the basis of what it buys, has a standard of living 32 per cent higher than in prewar 1940, and 40 per cent higher than in boomtime 1929. The home of the typical American family supplies the base for rising standards of living. Today more than 28.5 million families own their own homes, compared with 15.2 million in 1940, and the number is growing. Now 37 million families—3/4 of the total—own automobiles, and 11 per cent of these families own two cars. And living in the homes is even better through the products which the people have. Just a few of these are shown in the following table.[2]

Name of Product	Per Cent of Homes Supplied
Electricity	98
Radio	98
Refrigerator	91
Running water	88
Electric iron	83
Flush toilet	80
Tub or shower bath	78
Washing machine	72
Telephone	69
Electric toaster	66
Television	61
Vacuum cleaner	56
Clothes drier	5
Air conditioner	3

The reason for this abundance is the progress which the engineer has made in production processes, from manual operation, through mechanization, into automation. The motivating force of the engineer has been "more products

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Essentially full text of the keynote address presented at the AIEE Rubber and Plastics Conference, Akron, Ohio, April 4–5, 1955.

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for more people at less cost." The tools which have made these figures possible are wonderful machines of every description, driven almost entirely by electric motors with electric controls, together with auxiliary mechanical equipment, and with instruments of every description. Only a relatively few people know about these tools, their potentiality, their power, and their scope. These few people are the engineers; they have provided the advances of the past and will provide the advances of the future.

As the engineer has brought mechanical power through electricity into production, the jobs for the people have increased. The figures show this dramatically:

Year	Percentage of Work Energy Supplied by Mechanical Power	Jobs (in Millions)
1880	17	17
1910	57	37
1930	84	45
1950	94	60
1954	95	62

Without this progress from manual operation, through mechanization, to automation, these results would never have been attained.

Between 1946 and 1952 the electric power used by each production worker rose from 10,750 to 16,350 kilowatt-hours, a 52-per-cent increase. In fact, the industrial use of power between 1946 and 1952 went up faster than industrial production itself, so that the electrical content of the average product increased by a significant 24 per cent. This pattern of industrial electrification is continuing upward, so that in 1964 more than 90 per cent of the nation's manufacturing horsepower will probably be electric. There is no doubt that the trend to automation is and will be the key factor in this growth.

STEPS TOWARD AUTOMATION

TODAY'S industrial interpretation of automation is continuous automatic production. It is a concept of manufacturing based on continuous flow, rather than intermittent batches of work. It embraces the automatic making, inspecting, assembling, testing, and packaging of parts and products in one continuous flow.

The word, at least, is new, even though Oliver Evans built a completely automatic flour mill near Philadelphia in 1874, and this means that there were no workers in the mill. But modern automation is still just barely started.

Automation is not a second industrial revolution. Its nature is evolutionary, not revolutionary. It is built upon a solid foundation of progressive step-by-step upgrading of both manufacturing operations and people, and is of itself a progressive process.

As an illustration of the progressive steps of industrial development that lead toward automation, consider the metal-working industry, which has many characteristics in common with other industries. First is the manual area of manufacturing: Many people combine to produce one unit at a time, first only by hand and then with the aid of hand tools and simple manual materials-handling equipment.

Next is the mechanization area, where mass production is the result of the introduction of the driven machine and simple conveyor. The addition of increasingly complex controls and materials-handling equipment leads up to the automatic stage, in which many operations can be performed. The job of the man on the production line has been limited to not much more than starting and stopping the automatic machine, whereas the amount of supporting, or indirect, labor required for the maintenance has actually increased. Thus the industry is ready for the beginning of automation.

Here is where continuous automatic production starts in a small way, with fully automatic machines integrated with transfer devices to perform a series of operations. The man on the production line has been trained and upgraded to become the skilled machine specialist or maintenance expert. By logical steps these machines are grouped into automatic units, then the units are grouped into an automatic system, the system into an automatic section, and finally some day the automatic factory can be expected. In the case of the rubber industry, the combining of more and more operations into the continuous processing fabric calender train is an example of this evolution toward automation that has been going on for several years.

It would seem obvious, from this long and challenging development problem, that the era of the so-called automatic push-button factory is still ahead. It certainly will not come by just the sudden uneconomic application of money or effort. Except in some process industries, such as chemical, petroleum refining, and some foods—industries where the products are fluid—automatic factories are rare, if they exist at all. For an average manufacturer to think of the "automatic factory" turning out assemblies or products today is purely wishful thinking.

Today the opportunities lie in doing the job at hand with the tools available; that is, progressively upgrading operations and people out of the mechanization and into the automation area. Automation, as such, will have to pay its way in a step-by-step program as industry takes a practical approach to the diligent use of each year's expanding technical advances in manufacture.

It is also true that automation is not limited to high-volume production items, such as refrigerators, lamps, or automobiles. In most of the industries today, operations can be found in all of the levels of mechanization. There is ample opportunity to move these operations at least one more step up the ladder. That means investing in more highly mechanized equipment rather than more buildings filled with the same old kinds of equipment and using the same old methods. New plants, however, may also be necessary.

THE BETTER WAY

ONE OF THE BEST mottoes ever coined for the engineer is: "There is always a better way." Thus, as the engineer studies and restudies each process in his industry, he will find new ways of doing it better, and at less cost. The moves toward automation will largely be the answer. The economics will classify the result. The engineer and the manager, working together, make the perfect team.

In the simplest analysis, a process has three basic ingredients: There are first, raw materials. Then there are operations upon the materials. Last, there is the final product. The machinery of production, the auxiliary mechanical equipments, the instruments and the controls, and the electric motors for power drive are available for practically every process operation. The systems engineering to bring these into co-ordinate relationships is available in advanced form. The doing of it is in the vision and the courage and the ingenuity of the engineer working with the manager. It is this relationship that has brought the profession to where it is today. It is this relationship that will carry it forward into the years ahead. And at meetings and conventions of engineers will come the inspiration and the ideas and the knowledge which will help them to do an ever-better job. There is always a better way.

In the rubber and plastics industries, the domestic consumption of rubber in 1954 was approximately 9 per cent below the all-time high of 1,338,000 tons in 1953. The expected increase in automobile and truck production in 1955 will be a major factor in an estimated 3-per-cent increase in consumption this year over 1954, or about 1,250,000 tons.[3]

The two areas of the chemical industry which use the largest dollar volume of chemicals, synthetic fibers and plastics, are expected to continue their enormous growth rate of doubling every 5 years. In cubic footage produced, plastics are exceeded by lumber, cement, steel, and rubber; plastics in turn exceed aluminum, copper, zinc, lead, and magnesium. Today about 60 per cent of all plastics production goes into industrial and military products, and the remaining 40 per cent goes into consumer products. Thus the plastics industry is, to a very large extent, dependent upon the general economy.[4]

The electrical manufacturing industry, as an example, must be able to double its present output by 1964. This is typical of the task facing all fast-growing industries. However, the predicted available work force will increase less than 13 per cent by 1964. The solution to this vital problem of obtaining increased industrial productivity, one of the great challenges and opportunities today, has come to be characterized by a word, perhaps the most misunderstood in modern vocabulary, this word "automation."

To the engineer it is fundamental. To the electrical engineer it is the advancement of electrical living. To the people of this country it means more goods for more people at less cost. It is America. It is for the engineer to learn about it, to study it, to apply it to his processes. It is for you, the electrical engineer, working with your management.

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Giant Remotely Controlled Band Saw Is Subject of Film

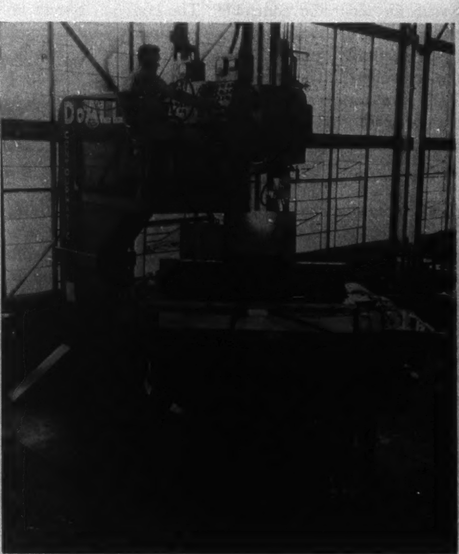
The various facets of development and use of the world's largest contour-cutting band saw were presented recently in a 16-mm color film, "Production Tooling," released by The DoAll Company, Des Plaines, Ill. It relates the story of how an extremely difficult tooling problem was solved with the band machine.

The problem concerned the cutting of the large dies for one of the largest aluminum-extrusion presses in use in the United States. Structural parts for aircraft are produced on this press under the Air Force's heavy press program. Excessive weight of the die blanks (up to 10 tons, and 52 by 26 inches in size) prohibited hand manipulation in sawing out the die aperture.

The camera work conveys a vivid impression of this band saw (15 feet high, 16,000 pounds), and close-ups show the details of cutting action and functioning of the electrically powered work tables.

The camera takes the viewer to the machine operator's station—a platform suspended from the machine head. There the operator is seen controlling the movement of three vertically stacked electronically synchronized tables, with a simple steering wheel.

A whole new realm of possibilities for the shaping of intricate parts is indicated by "Production Tooling."



Electronic Processing of Air-Traffic-Control Information

By R. M. KALB MEMBER AIEE

Flight plans and weather information are transmitted and received automatically over teletypewriter lines. Messages are filed in a magnetic drum storage and can be found by means of their contents. Any questionable or obviously erroneous message is printed out for review.

A NEW kind of electronic system has been developed as part of an over-all nation-wide air-traffic-control plan[1,2] to accommodate the increasingly pressing problem of dispatching air traffic. In recent years this problem has been aggravated by a growing volume of all sorts of traffic to be monitored—military, private, and commercial—and planes operating at higher speeds have reduced the time available for action. The terminal control problem is complicated by greater landing speeds and by the widening range of speeds of approaching aircraft. At one end of the speed range are found helicopters, at the other end jet airplanes. The trend to all-weather flying imposes a severe terminal problem when planes are landing and taking off under poor weather conditions. The problem of handling today's air traffic, and that of tomorrow, is being resolved under the planning of a common system for air-traffic control.[3,4] The common system includes navigational aids, air-borne equipment, and ground-based electronic aids for the men who control the air traffic, the controllers. The subject equipment of this article—a flight plan storage and processing equipment—provides, as part of these ground-based aids, a high-speed unindexed electronic filing system.

CONTROL OF AIR TRAFFIC

CONTROLLERS who monitor the cross-country air traffic are located in air-route traffic-control (ARTC) centers, about 25 in number. These communicate with airplane pilots and dispatchers through about 500 stations. Three fourths of these stations handle communications only, the other fourth are control towers at important airports. The geographical area handled by one ARTC center varies greatly according to the density of surrounding air traffic and may contain anywhere from two to seven control towers. The controllers stationed in control towers are concerned only with immediate departures and arrivals of planes at their airport. In handling a flight from take-off to touchdown, both kinds of controllers take action, but those at the ARTC centers exercise the continuing monitoring control.

The electronic system makes information on all pertinent flights available quickly to a controller when the time for his action approaches, and otherwise on demand. It receives and delivers weather reports automatically and keeps a file of the flight plans for all air traffic within an area. Table I lists the contents of these types of messages. Routine processing of the information is done automatically. Facilities are provided for altering the filed information and for keeping it up to date. A permanent record is made of all the information handled in the system.

Flight Plans. Air-traffic information filed is in the form of flight plans. A flight plan is an itinerary of an aircraft plus pertinent data about the craft. Airways, like highways, are designated by route codes. An airway code is a color and a number, e.g. *GREEN 14* or *RED 9*. Thus it is possible to construct an itinerary by a sequence of codes and reporting points, or "fixes," with the altitude of each portion of the route also given. Such a plan is originated by the pilot or by a dispatcher, and may be presented via teletypewriter message, voice, radio, or on a written form. The information is reduced to a standard format and put on teletypewriter lines for introduction into the system. A flight plan received in teletypewriter code can enter the electronic system directly; received in any other form it is relayed through an operator who prepares the proper teletypewriter message.

Each flight plan message comprises the following portions:

1. *Teletypewriter address* signals for automatic line switching and machine clearing (6 characters).
2. *A preamble* consisting of the address from which the message is sent and codes for the kind and length of message (6 characters).
3. *A criterion* of message selection consisting of the departure time and airport, and the aircraft identity number (18 characters).
4. *General information* including arrival time and airport and an alternate arrival airport, plane type, instrument

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Full text of paper 55-147, "An Electronic System for Processing Air-Traffic-Control Information," recommended for publication by the AIEE Committee on Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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The system described was developed for the Air Navigation Development Board, Civil Aeronautics Administration, Technical Development and Evaluation Center, under Contract *C13ca-410* by Engineering Research Associates, Division of Remington Rand, Inc., St. Paul, Minn.

The Air Navigation Development Board (ANDB) was established by the Departments of Defense and Commerce in 1948 to carry out a unified development program aimed at meeting the stated operational requirements of the common military/civil air navigation and traffic control system. This project, sponsored and financed by the ANDB, is a part of that program. The ANDB is located within the administrative framework of the Civil Aeronautics Administration for housekeeping purposes only. Persons desiring to communicate with ANDB should address the Executive Secretary, Air Navigation Development Board, Civil Aeronautics Administration, *W-9*, Washington 25, D. C.

TABLE I. CONTENTS OF MESSAGES FILED

	Flight Plans		**Weather Reports**
6 characters	**Signals** for Teletype line switching and machine clearing		Same
6 characters	**Preamble**	Address Kind of message Length of message	Same
18 characters	**Criterion**	Departure time Departure airport Aircraft identity	Time of observation Place of observation The word "WEATHER"
35 characters	**General information**	Arrival time Arrival airport Alternate arrival airport Type of aircraft Speed of aircraft Fuel (in hours) Instrument equipment Priority of flight Restrictions on course	Text of report
17 characters (1 to 9 sets)	**Route information**	Airway Altitude Fix and time	Text continued
3 characters	**Sign off**	Figures shift Carriage return Letters shift	Same

TABLE II. LIST OF MESSAGES PROCESSED BY THE SYSTEM

Nature of Action to Be Initiated	**Contents of Incoming Message**	**Contents of Normal Outgoing Message**	**Contents of Outgoing Alarm Message†**
File Flight Plan	Complete Flight Plan	Complete Flight Plan	Conflicting Preamble and Criterion
Activate Flight Plan	Time Signal	Complete Flight Plan	None
Modify Flight Plan	Complete Flight Plan	Complete Flight Plan	None
Read out Flight Plan	Criterion and Preamble	Complete Flight Plan	Received Preamble and Criterion
Cancel Flight Plan	Criterion and Preamble	Complete Flight Plan*	Received Preamble and Criterion
File Weather	Complete Report	Complete Report	None
Read out Weather	Criterion and Preamble	Complete Report	Received Preamble and Criterion
Cancel Weather	Criterion and Preamble	Complete Report*	Received Preamble and Criterion

* To legal storage.
† For logical inconsistencies. If format is erroneous the received text is relayed to supervisory controller.

TABLE III. DATA ON STORAGE SYSTEM

Capacity	2,000 messages	1,250 short—115 characters maximum 750 long—230 characters maximum
	330 tracks	285 message store 30 recirculating registers 15 timing and format control
Speed	1,190-rpm drum	22 inches diameter, 30 inches long
	114-kc pulse rate	For timing circuits
	22.8-kc pulse rate	For read/write circuits
	410 milliseconds maximum search time	8 drum revolutions
Size	$31\frac{1}{2}$ feet long $2\frac{1}{2}$–3 feet wide 7 feet high	Plus 3-foot by 5-foot console and 2 cooling units each $2\frac{1}{2}$ feet by $3\frac{1}{2}$ feet and $7\frac{1}{2}$ feet high Total floor space 15 feet by 25 feet
	1,988 tubes	*7AK7* and *5963* types predominate
Power	27.2 kva	Includes 2.2 kva for cooling units

equipment, speed, fuel, and priority, and any restrictions applicable to the flight (35 characters).

5. *Route information* consisting of airway, altitude, fix, and time (1 to 9 sets of 17 characters each).

6. *Sign-off*, figures shift–carriage return–letters shift, to denote the end of the message (3 characters).

Messages handled by the system are tabulated in Table II. They include both flight plans and instructions concerning the disposition of flight plans. Incoming flight plans to be filed constitute one type of message. Flight plans which modify an already existing one are messages of a second type. Instructions may be to read out a particular flight plan, to cancel one, or to activate one whose departure time is imminent; these three kinds of instructions form three more types of message. The system includes provision for storing weather reports as well as flight plans, and the filing, reading out, and cancelling of such reports occasions three more message types. A reply or an alarm message is generated in each case to complete a cycle of action by the system.

NATURE OF THE AUTOMATIC OPERATIONS

In processing a received message of any type, the system attempts a sequence of four logical steps. These steps, with their logical alternatives, are diagrammed for the filing process in Fig. 1. The first step is to verify the format of the message in certain respects to make certain that the message is properly composed for the system. The next is to search the file of stored information. This search is made according to the nature of the incoming message, either to guard against accepting a duplicate message or to find a stored message which is to be modified or cancelled. The third logical step is disposal of the message. This step may be to store the message or to read out, modify, or cancel one already stored. See Fig. 2 for details. Finally a reply is prepared which gives external indication that the action initiated has been completed or that it cannot be.

Failure of the system to comply or its inability to proceed with any logical step initiates an alarm message. If the format of the incoming message fails verification, the message as received is printed out to a supervisor at the machine center, who then handles the situation by the exercise of his own judgment. All other alarms result in the composition of a message containing only a preamble and criterion. If a flight plan received for filing has the same aircraft identity number and departure airport as a plan already stored, that plan is rejected and the preamble and criterion of the plan in file are transmitted to the sender, who thereby is advised of the conflicting plan and who then can take further action by cancelling it before filing the new one or by having all of the filed plan read out to him as the basis for deciding further action.

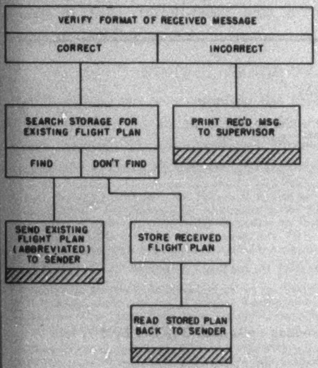
As soon as a message is filed initially, the complete text of the message is read back from storage and transmitted to the sender. This gives him at once a verification and a typed copy of the flight plan he has on file. When any message in file is cancelled, it thereupon is read out in its entirety to a tape perforator; the record of this perforator, termed legal storage, constitutes a complete listing of all messages upon which action has been completed. Tape from the perforator can later be fed into a page printer to reproduce a typed copy of any desired portion of the record.

The system deletes spaces from the received message before storing the information contained in it, and restores the spaces as the message is read out. This action is based on a fixed format for each type of message.

Buffer registers, called incoming-message-holding units, receive messages as they arrive and introduce them into the storage system when it is ready, after they have been verified. An outgoing-message-holding unit similarly accepts the stored information necessary for a reply and relays it to a teletypewriter line as available. Incoming- and outgoing-message-holding units operate in pairs; an incoming unit will accept a message but will not process it into the system until the incoming unit has acquired a complementary outgoing-message-holding unit to receive the reply. The preamble of the incoming message is transferred directly to the outgoing-message-holding unit for utilization by it in formulating the reply message.

A high-speed message-holding unit is provided also. This is a dual unit which handles information both ways between the storage system and a display panel console at speeds one order of magnitude greater than in the teletypewriter lines.

A special feature of the system is a clock-actuated read out. By action of this device, the storage is searched completely every 10 minutes and all plans for flights due to de-


VERIFY FORMAT OF RECEIVED MESSAGE
CORRECT
INCORRECT
SEARCH STORAGE FOR EXISTING FLIGHT PLAN
FIND
DON'T FIND
PRINT REC'D MSG. TO SUPERVISOR
SEND EXISTING FLIGHT PLAN (ABBREVIATED) TO SENDER
STORE RECEIVED FLIGHT PLAN
READ STORED PLAN BACK TO SENDER

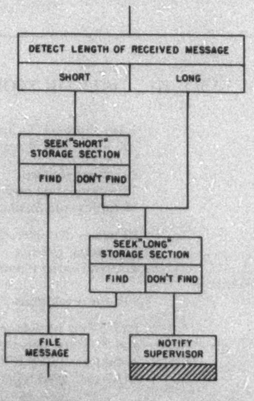

DETECT LENGTH OF RECEIVED MESSAGE
SHORT
LONG
SEEK "SHORT" STORAGE SECTION
FIND
DON'T FIND
SEEK "LONG" STORAGE SECTION
FIND
DON'T FIND
FILE MESSAGE
NOTIFY SUPERVISOR

Fig. 1 (left). The logical sequence of filing a flight plan.
Fig. 2 (right). Subsidiary logic of the storing operation

part within the succeeding 20 minutes are selected automatically and transmitted to the airport of departure. When a flight plan is so activated, a status indexing character filed with it by the system is changed to indicate "en route status." This indication prevents the same flight plan from being read out automatically again during a subsequent periodic review. Provision is made also for filing plans with an en route status initially. This is done when the plan is filed within 10 minutes of its departure time or when the controller modifies a plan already under his scrutiny.

PROPERTIES OF THE EQUIPMENT

PERTINENT numerical characteristics of the equipment are given in Table III. The filing system utilizes magnetic drum storage with a capacity of 2,000 flight plans and weather reports. These are grouped into two categories: short and long. A short message consists of not more than 115 characters, a long message can be twice as long. Information is stored in the teletypewriter code with the characters serial and their five bits in parallel. The total information storage capacity of the drum is 316,250 characters or 1,581,250 bits.

Stored information is so arranged that during the search only the criterion portion of each message is scanned. With this arrangement, the entire contents of the information store can be searched in eight drum revolutions, approximately two fifths of a second.

The timing pulse rate of the drum is 114 kc. Using a fivefold interlace, information is read and written at about 23 kc. Conversion between the teletypewriter line speed of 460 characters per minute and internal system speeds of 23,000 characters per second is accomplished through the incoming- and outgoing-message-holding units. More details descriptive of the equipment are published elsewhere.[5]

A complete set of the equipment which forms the system described has been installed for evaluation at the Technical Development and Evaluation Center of the Civil Aeronautics Administration at Indianapolis, Ind. An overall view of the installation there is shown in Fig. 3. This installation is being connected to operate through an automatic teletypewriter switching center[6] (a modified *81D1* system), and in co-operation with data transfer and display equipment described in a companion paper.[7]

FUTURE PLANS

PLANNING for the air-traffic-control system calls for dividing the country into control zones, perhaps 10 or 15 altogether, and centralizing the control for each zone in one similar equipment located within it.[8] When this is done, equipments for adjacent zones would be connected by teletypewriter lines with automatic switching, so that two equipments could "converse" with each other to establish flight plans for interzone traffic. The system logic for such operation was examined prior to planning the present system, and it was designed according to principles which will allow such interconnection of equipments.

Requirements for the ultimate system will not be known until after the present one is evaluated. One matter to be settled concerns the relative demands for weather and traffic information and whether such information should be filed on one equipment, as in the present instance, or on separate equipments.

Courtesy of CAA Technical Development and Evaluation Center

Fig. 3. The flight-plan storage and processing equipment

Another question to be determined is the possible need for adding a time reservations facility to the system.[9] The purpose of this facility would be to limit the number of scheduled landings and take-offs during periods of an hour or less for each airport. The limit would, of course, have to be variable because of the influence of weather and other conditions which affect the acceptance rate of an airport. The means for including time reservations in the air-traffic-control system were worked out during the early planning of the present equipment, and it was so planned as to permit the addition of the time reservations feature to subsequent models.

The system described constitutes an initial venture into automatic teletypewriter filing and processing of alphabetical and numerical information. It is also the first serious attempt to mechanize the routine of handling air-traffic-control information. With the possibility realized of machines composing messages and conversing via teletypewriter lines, facilities are at hand to further the advance of clerical procedures by means of electronics.

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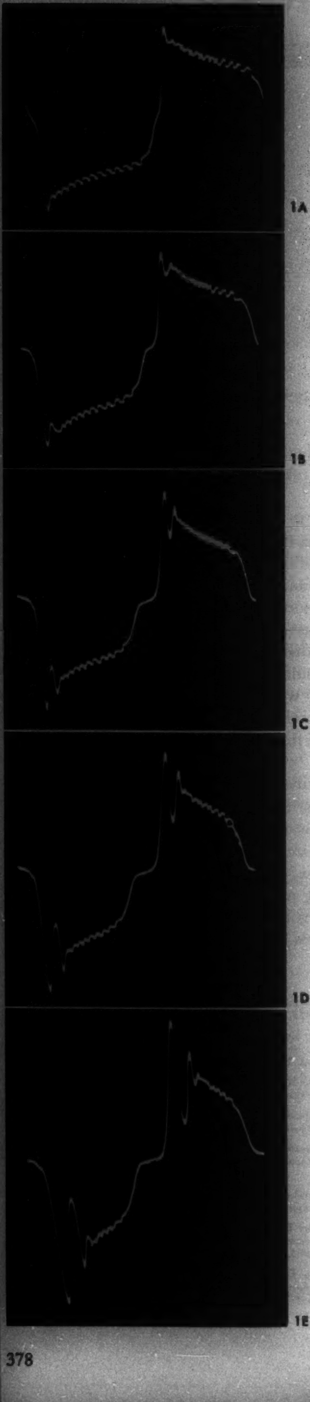
Variable-Reactance Dimming Control for Fluorescent Lamps

by D. D. KERSHAW



THE INTRODUCTION OF THE FLUORESCENT LAMP in 1939, provided the lighting profession with a new and versatile type of light source. The wide public acceptance of fluorescent lighting has been due to its inherent advantages such as high efficiency, low brightness ratios, better light distribution, and a large selection of lamp sizes and colors. The lighting industry with its innumerable lighting problems may require new sizes of fluorescent lamps, improved colors, and lamps with special brightness characteristics to serve in new applications. The need for fluorescent lamps in new lengths, diameters, and wattages will continue; however, it is known that many new and existing applications could be given additional flexibility if the brightness of the lamp were controllable.

A satisfactory means of controlling the brightness of a fluorescent lamp has long been the goal of people associated with the lighting industry. Several methods of dimming fluorescent lamps have been developed and used to some extent in the United States and in Europe. Probably the simplest method of controlling the brightness of a fluorescent lamp can be found in primary voltage control. In a system of this type, the voltage of the primary of an instant-start ballast can be varied by means of a variable autotransformer to give a limited change in brightness. This system is limited to a brightness change of approximately two to one because an instant-start type of fluorescent lamp requires a minimum current of approximately 100 milliamperes (ma) in the arc to maintain the electrodes at a satisfactory electron-emitting temperature.

Cold-cathode types of fluorescent lamps operate in a slightly different manner from the more commonplace hot-cathode types.[1] The cold-cathode lamp is designed to emit electrons from its cathode by field emission while the hot-cathode fluorescent lamp emits electrons by means of thermionic emission. Because of the different modes of operation of the cathodes, the cold-cathode lamp can be operated over a wider range of current than the instant-start hot-cathode lamp, thereby giving a greater range of brightness (ten to one). The maximum light output of cold-cathode fluorescent lamps is, however, lower than hot-cathode lamps due to the limitation of lamp current to a maximum value of approximately 200 ma. In general, a cold-cathode dimming system consists of a high-voltage high-reactance transformer with a relatively large number of lamps connected in series.[2] Dimming is accomplished by varying the primary voltage. This system has the disadvantage of poor starting characteristics at the low-brightness levels.

Fig. 1 (left). Lamp voltage with control reactor set: *A—100% brightness; B—80% brightness; C—60% brightness; D—40% brightness; E—20% brightness*

Variable-reactance-type dimming provides a new method of brightness control for fluorescent lamps. It has the advantage of smooth dimming over a wide range, from 50 to 1, as well as high efficiency and low cost. There are many possible applications where the utilization of this type of dimming control will add to the flexibility and novelty of an installation.

In recent years there has been a growing demand in the lighting fields for a method of controlling the intensity of light produced by fluorescent lamps. In 1952 a new type of dimmer was made available to the lighting industry.[3] This unit is referred to as an electronic dimmer.

The electronic dimming system has provided lighting specialists with a new tool which increased the flexibility of fluorescent lamps. This system is capable of providing smooth dimming over a range of 100 to 1 in brightness (to 1 per cent of maximum). In addition, the system provides reliable starting voltage throughout its dimming range. The electronic dimmer is comprised of three basic elements: a pair of thyratrons; a brightness selector; and a ballast that provides continuous heat to the electrodes of the fluorescent lamp. In the past 2 years more than 100 installations of the electronic dimmer have been made in stage, auditorium, office, night club, and similar applications. The expanding interest in fluorescent dimming stimulated the development and design of the dimming system described herein. It became apparent that there was a need for a low-cost dimming system for home applications and small commercial installations where the advantages of the more flexible, but more expensive, electronic dimmer control are not needed. It is the intention of this article to describe a new method of brightness control having the advantages of smooth dimming over a wide range (50 to 1), high efficiency, and low cost.

CIRCUIT REQUIREMENTS FOR DIMMING

THE CHARACTERISTICS of a fluorescent lamp are complex and require basic consideration in order to design auxiliary equipment that will give stable control. Since all electric-discharge devices have a negative resistance characteristic, a ballast is required in series with the lamp to limit the current. Dimming fluorescent lamps requires that the arc current of the lamp be varied from a nominal value down to a current of approximately 1 ma. The operation of a fluorescent lamp below a certain current level, approximately 100 ma, is limited because the cathodes of the lamp rely upon the current density of the arc to maintain its electron-emitting temperature. If the current density of the arc goes below 100 ma the cathode tends to decrease in temperature. This results in an increase in the voltage drop at the cathode and consequently an increase in the lamp voltage. Since the relationship between the lamp voltage and the ballast voltage changes rapidly at this point, the lamp becomes unstable and extinguishes. To avoid this condition the ballast circuit should be designed to heat the electrodes of the fluorescent lamp continuously throughout the dimming range.

If stable operation of a dimming system at the low end of the dimming range is to be achieved, the voltage available to the lamp on each half cycle must be sufficient to reestablish ionization within the lamp. Fig. 1 illustrates the change in lamp voltage at various brightness levels. From

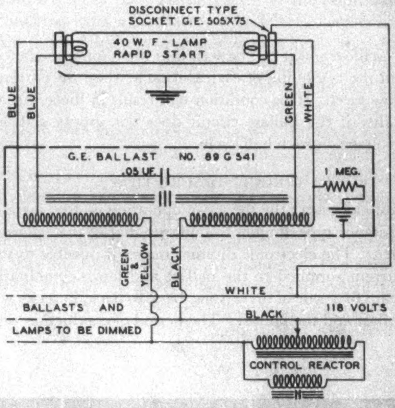


Fig. 2. Circuit diagram of variable-reactance dimmer

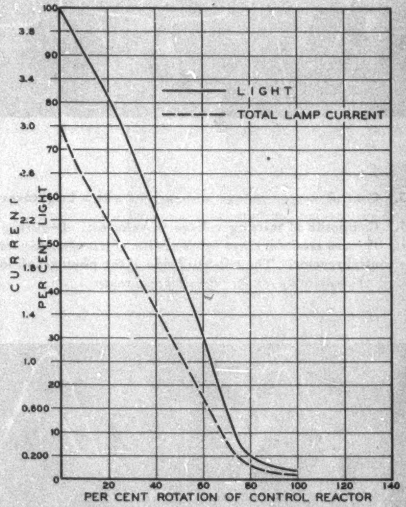


Fig. 3. Light output and control reactor current versus rotation of control reactor for light and total lamp current

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Full text of a paper presented before the AIEE Cleveland Section and recommended for publication by the AIEE Committee on Production and Application of Light.

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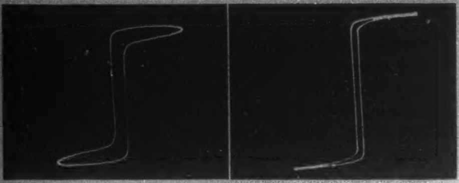
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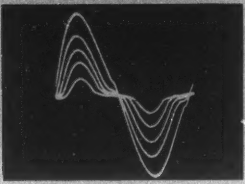
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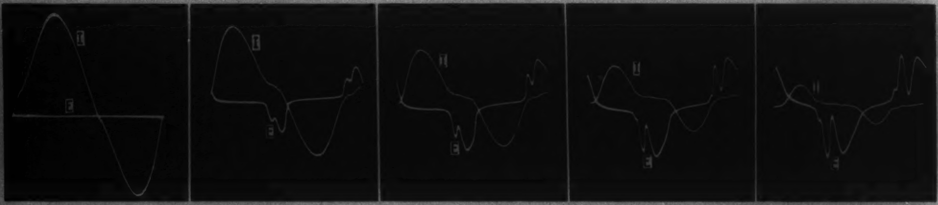
Fig. 4. Control reactor B-H curves: *A—control setting of 80% brightness; B—20% brightness.* **Fig. 6. Lamp current waveform at 100% brightness, 80% brightness, 60% brightness, 40% brightness, and 20% brightness**

these oscillograms it can be seen that the lamp impedance is high at the beginning of each half cycle when the current is at a low level. This condition will result in flickering and instability if the ballast circuit does not supply sufficient peak voltage on each half cycle.

CIRCUIT DESCRIPTION

In some respects the theory of operation of the variable-reactance-type dimmer is similar to that of the electronic dimmer. The electronic dimmer makes it possible to vary the current supplied to the ballast and lamp combination by means of a pair of thyratrons, back to back, in series with the ballast and the lamps. The period of conduction time, each half cycle, is controlled by the thyratrons and the average current to the fluorescent lamp can be varied by controlling the phase of the grid voltage of the thyratrons. In a similar manner the reactance-type dimmer provides a variable impedance in series with the lamp and ballast to effect a change in arc current in the fluorescent lamps.

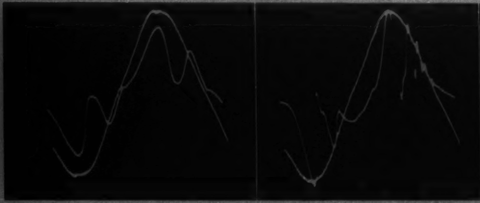
The reactance-type dimmer, as shown in Fig. 2, utilizes a 40-watt rapid-start fluorescent lamp, a special rapid-start ballast, and a variable reactor for control (modified variable autotransformer). The ballast is designed to provide voltage for heating the electrodes of the fluorescent lamp to a constant value throughout the dimming range. In addition, the magnetic circuit of the ballast is arranged to



5A 5B 5C 5D 5E

Fig. 5. Control reactor voltage and current with a brightness of: *A—100%; B—80%; C—60%; D—40%; E—20%*

Fig. 7. Composite of starting voltage waveforms: *A—starting voltage at 100% brightness (sine wave) and 2% brightness without compensating reactors; B—same conditions except for the addition of a compensating reactor.* **Fig. 8. The starting voltage available for any brightness position of the control reactor. The left-hand side of the photograph indicates the 100% light output position:** *A—starting voltage over the dimming range without compensating reactor; B—same with reactor*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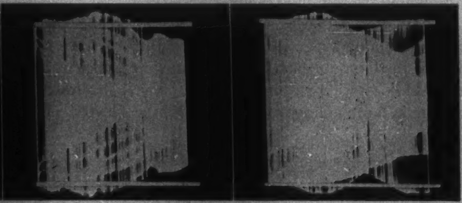
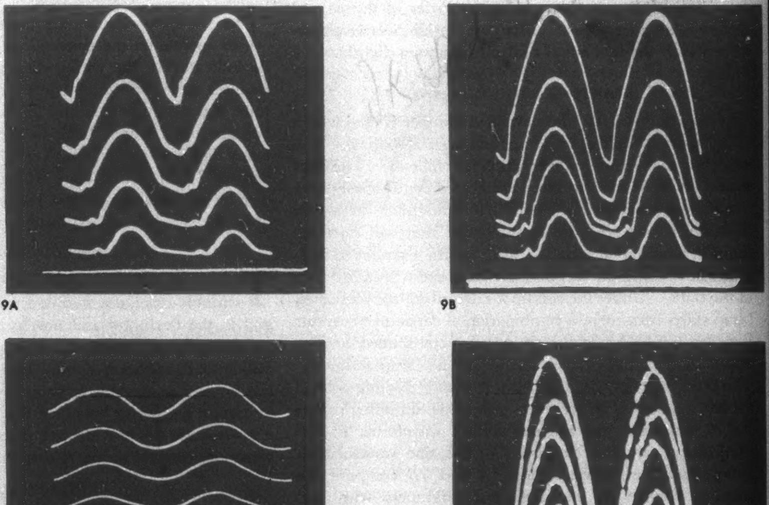

8A 8B

provide the voltage required for starting, and the proper impedance to limit the lamp current. The control reactor can be varied from zero to full impedance by rotation of a knob. One end of the control reactor is connected to the green-yellow leads on the dimming ballast and the variable contact is connected to the black side of the line. In a circuit arrangement of this type the control reactor provides a variable impedance in series with the lamp and ballast combination. The total current in the control circuit is equally divided between the number of ballasts and lamps. The load current can be varied uniformly by rotating the control knob. The addition of a small compensating reactor in parallel provides better control at the low end of the dimming range and increases the starting voltage.

The relationship between light output and control-reactor current versus per-cent rotation of the control reactor is illustrated in Fig. 3. The curves illustrate the characteristics of an 8-lamp dimmer. However, other sizes of dimmers have nearly identical characteristics. The impedance characteristics of the control reactor allow the light to vary in a uniform manner up to approximately 75-per-cent rotation of the control. The inflection in the curve at this point is characteristic of the magnetic material used in the control reactor. The light output tapers off at a slower rate at the low end of the dimming range for a given rotation of the control reactor; this is not a disadvantage as the eye is more sensitive to low-level light changes.

Fig. 4 illustrates the magnetic characteristics of the control reactor at 80-per-cent and 20-per-cent light output. The sharp *B-H* curves are indicative of the grain-oriented type of iron used in a typical control reactor. The control reactor is in saturation over 75 per cent of the dimming range. In fact, the inflection in the curve shown in Fig. 3 is due to the sharp change in impedance of the control reactor as it drops out of saturation. This sudden change in impedance gives an undesirable effect since the brightness of the lamps will change abruptly. In order to compensate for this effect a second reactor indicated in Fig. 2 is placed in parallel with the control reactor. The compensating reactor is designed to be equivalent to the impedance characteristics of the control reactor at the point where it is changing from a saturated to an unsaturated condition. With this modification of the basic circuit the dimmer provides a smooth control of brightness at the low levels.

The oscillograms in Fig. 5 show the voltage and current relationship of the control reactor. Fig. 5*A* represents the condition with the control reactor in a full-brightness position. Since the reactor is at zero impedance, the voltage across it is likewise zero. As the lamps are dimmed, the voltage across the reactor increases and the current through it decreases. An interesting characteristic of the dimming circuit is the ability of the circuit to dim a number of lamps less than the full capacity of the dimmer. The removal of a lamp from the total dimming load has a negligible effect on the light output of the remaining lamps since the reactor is operating in a saturated condition and will absorb the


9A

9B

9C

9D

Fig. 9. Stroboscopic effect of various colors of fluorescent lamps at 100% brightness, 80% brightness, 60% brightness, 40% brightness, 20% brightness: *A—de luxe warm white; B—standard cool white; C—red; D—blue*

same voltage even with large changes in load. However, the light output does increase in the remaining lamps if a lamp is removed at the minimum brightness. The increase in light output per lamp remaining in the load is approximately 1 per cent of maximum for each lamp removed from an 8-lamp dimmer. Therefore, if an 8-lamp dimmer is used to operate only four lamps, the effective dimming range is reduced from 50 to 1 to 17 to 1. In larger dimmers, 22-lamp or 44-lamp, the increase in light output due to a lamp load less than full capacity would be of the order of one half to one quarter of 1-per-cent full brightness per lamp, depending on the size of the dimmer.

The entire cycle of the lamp current waveshape for various brightness levels is shown in Fig. 6. These points correspond to light outputs of 100, 80, 60, 40, and 20 per cent.

RANGE OF DIMMING

To obtain the maximum dimming range with any known type of dimmer, the lamps should be seasoned for 24 hours or more. This allows the lamps to stabilize, resulting in more uniform electrical characteristics of the individual lamps. It is preferable to season the lamps at full brightness when they are first installed. The range of dimming accomplished with the variable-reactance-type dimmer is approximately 50 to 1, i.e., dimming down to 2 per cent of full brightness. The minimum lamp brightness possible also depends on the line voltage and the individual characteristics, core losses, of the control reactor. The normal line voltage changes will cause a variation in the light output of $1^{3}/_{4}$ per cent for each 1 per cent change in line voltage. It is impossible to hold the characteristics of the control reactors to exact values. Minimum brightness levels obtained with the individual controls may vary slightly.

STARTING REQUIREMENTS

As stated earlier, the simplified dimmer is used with a 40-watt rapid-start lamp and special ballast. The principle of starting and operation is as follows: The electrodes of the fluorescent lamp are heated continuously by a low-voltage winding in the ballast. In addition, the ballast is designed to have an output voltage that will start the lamp in a grounded metal fixture, or with a grounded strip of metal running the length of the lamp and within 3/8 inch of the bulb. Under the conditions described, the preheated lamp starts because of a combination of capacitive currents between the bulb and the grounded metal fixture, and by application of the proper voltage at the lamp terminals. The reactance dimmer will provide reliable starting voltage for the fluorescent lamps over most of the dimming range. Fig. 7 illustrates the starting voltage waveforms at the minimum brightness compared to the sine waveform at 100-per-cent brightness. Figs. 7*A* and 7*B* compare the starting voltage at the minimum brightness with and without the compensating reactor. The purpose of the compensating reactor is twofold. It not only makes the impedance changes in the control reactor more uniform but also increases the peak voltage applied to the lamps each half cycle. The increase in peak voltage as shown in Fig. 7*B* increases the stability of the dimming system at low brightness levels and also provides for reliable starting at the minimum point. The voltage available for starting a lamp is illustrated in Figs. 8*A* and 8*B*. The photographs were taken with the control reactor rotated from 100-per-cent light, left-hand side of illustrations, to minimum light, right-hand side of illustrations, to show the voltage available for starting the lamps at any position in the dimming range. Here again the effect of the compensating reactor on the peak starting voltage is illustrated.

STROBOSCOPIC EFFECTS

The light from a fluorescent lamp is made up of two components; one is a steady value and the other varies at a cyclic rate. The amount of flickering light with respect to the steady light varies with the decay rate of the phosphor used.[4] Fig. 9 illustrates the flicker and steady-state components of light from various types of phosphors. In Fig. 9*D* a blue fluorescent lamp indicates that the decay rate of the phosphor is practically instantaneous compared to the line frequency. On the other hand, Fig. 9*C* represents the light output of a fluorescent lamp with a red phosphor which has a fairly long persistance. The Stroboscopic illustrations show the light output at points corresponding to 100, 80, 60, 40, and 20 per cent of full brightness with the bottom line being the zero light reference level. The measureable per-cent flicker increases as the lamps are dimmed to the minimum position. However, the flicker is actually less apparent to the eye as the brightness decreases, resulting in very little change in perceptible flicker from maximum to minimum brightness.

WIRING AND CONTROL

The variable-reactance dimming system is designed to operate on the conventional 120-volt 60-cycle lines. As indicated in the wiring diagram the dimming system requires three connecting wires: two are power lines; the third is the dimming control line which is connected to all ballasts and brought back to the dimming control. In many lighting applications, remote brightness control is desired. This can be done with the reactance-type dimmer by selecting the proper motor size; the size depends upon the torque required for the specific dimming control.

APPLICATIONS

There are many lighting applications in which the variable-reactance fluorescent dimmer can be used to add to the flexibility and novelty of an installation. Examples are homes, stores, offices, display areas, and luminous ceilings. In the home-lighting field, the fluorescent dimmer can be used to control the valance lighting for a change in atmosphere. Living-room lighting can be varied in brightness or color to provide the desired conditions for conversation, entertainment, television, and home movies.

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Determining Economical ACSR Conductor Size

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R. P. HUBER

IN converting a part of its distribution system from 4 kv to 13 kv, the use of steel-reinforced aluminum cable (ACSR) for main feeder line construction for the first time was decided upon by the Indianapolis Power and Light Company. As with other types of conductors, it was necessary to limit the number of sizes to reduce stocking problems.

At the start sizes and stranding can be considered. A minimum size of #2/0 is the smallest conductor with capacity to carry the maximum load of 260 amperes for which the circuits are to be designed. A maximum size of 397.5 thousand circular mils (MCM) was taken since any larger sizes would require different insulators, hardware, and a heavier class pole than normally employed, and it is estimated this would make the use of larger sizes uneconomical.

First, the most economical wire size for each value of load up to the maximum of 260 amperes was determined. This was based on an annual cost comparison of loss charges and the fixed charges on the installed cost of the conductor only. Hardware and pole costs would be approximately the same for any size as they are determined by other factors on our system. The curves of Fig. 1 give the results of this comparison, from which sizes can be selected:

0– 54 amperes	#2/0
54– 96 amperes	266.8 MCM
96–114 amperes	336.4 MCM
114–260 amperes	397.5 MCM

Since the 397.5 MCM is approximately the same in annual cost as the 336.4 MCM over the portion of load in which the latter is the lowest, extension of the 397.5 MCM to cover this section also can be made.

Second, the use of the above three sizes for serving a growing uniformly distributed load was explored. The curves in Fig. 2 show the annual costs for combinations of two sizes and of all three sizes in a graded construction arrangement. It was proved mathematically that the most economical arrangement for a 2,000-kva initial load with 11.6-per-cent load growth per year would be the use of 397.5 MCM for 44.4 per cent of the total length, 266.8 MCM for 26 per cent, and #2/0 for 29.6 per cent. Line length is no factor except from the voltage regulation standpoint. For a 10-mile line, a typical length for the system, the regulation can be taken care of by one set of voltage regulators and a 300-kilovar capacitor bank installation out on the line, in addition to bus regulation at the substation. This will limit the regulated primary section voltage drop at an ultimate circuit loading of 6,000 kva to the design limit of $4^1/_2$ per cent.

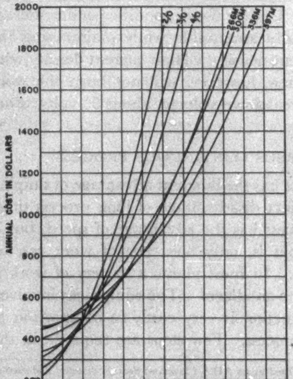

Fig. 1. ACSR distribution conductor annual cost comparison

Line length—1 mile, static load concentrated at end of line, line cost includes conductor costs and installation labor only, loss cost—$32/kw, fixed charges—15.5 per cent

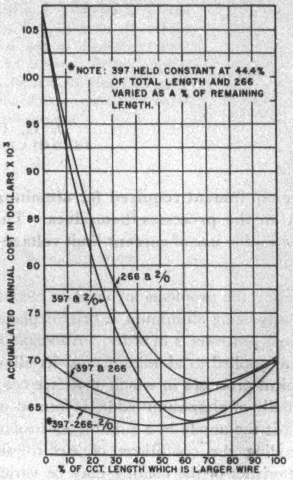

Fig. 2. Economical proportions of ACSR conductors in distribution circuits

Uniformly distributed load along line, length of conductor—10 miles, initial load—2,000 kva, final load—6,000 kva, rate of growth—11.6 per cent, period of time—10 years

It was concluded from this study that the sizes #2/0, 266.8 MCM, and 397.5 MCM of ACSR conductor would best meet the requirements of standardization and economy. Use of all three sizes in a graded construction arrangement, in which approximately one half the distance is 397.5 MCM and the other half is composed of equal lengths of 266.8 MCM and #2/0, gives the most economical arrangement for fairly uniform circuit loading. If load patterns vary it is necessary to alter the conductor size accordingly.

Digest of paper 55-159, "A Method for Determining Economical ACSR Conductor Sizes for Distribution Systems," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Electric Equipment for Aluminum Anodizing

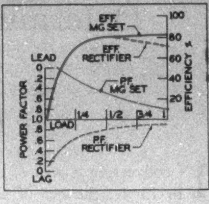

Fig. 1

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The electric equipment required for aluminum anodizing is described together with background information on the processes themselves. The advantages in simplicity and increased production obtained by the use of current-limit voltage-regulated motor-generator control are outlined.

BEFORE considering the problems involved in electric equipment for anodizing aluminum, a brief explanation of the various processes is in order. Anodization or anodic treatment as applied to aluminum and its alloys refers to electrochemical processes in which a surface coating, consisting essentially of aluminum oxide, is formed on the metal by making it the anode in a suitable electrolyte and carefully controlling the conditions of electrolysis. The physical characteristics of the coating may be varied considerably and depend upon a specific combination of the electrolyte, voltage, current, and temperature. A variation in any of these parameters will usually result in a change in the characteristics of the coating.

COMMON PROCESSES

A COMMON PROCESS used in the United States is the sulfuric acid or aluminite process. The process is generally performed by applying a low potential between the anode, which is the work to be processed, and the cathode, which is generally a lead-lined tank containing the electrolyte. This potential is increased as rapidly as possible without overloading the power supply to 18 volts, where it is maintained for 30 minutes. This voltage build-up period is required in all anodizing processes and will be explained in the section on control. According to government specifications, the process may be used for all parts fabricated from aluminum alloys except assembled parts subject to stress and containing joints or recesses in which the solution may be retained.

The method used far more than any other is the 5- to 10-per-cent chromic-acid process. This process is conducted in a steel tank acting as the cathode and containing the electrolyte. A low potential is applied to the electrodes and, without exceeding the capacity of the power supply, the voltage is increased as rapidly as possible to 40 volts, where it is maintained for 30 minutes. According to government specifications, this process may be used for all aluminum alloys containing less than 5-per-cent copper.

Under some conditions, it is necessary to consider current density at the anodic contact surface of the work. Burning at the contact points can occur if adequate contact area cannot be provided. This condition arises with various alloys and on materials with an inability to dissipate heat rapidly from the contact surfaces—such as thin sheets, or materials to which it is difficult to make contact—such as irregular castings. Under these conditions, the voltage is increased as rapidly as possible while maintaining the maximum safe current density. High current density with adequate contact area, however, will not burn the work provided the film breakdown voltage, about 55 volts, is not exceeded.

BATCH VERSUS CONTINUOUS PROCESS

THE batch process has the inherent advantage of simplicity, but the distinct disadvantage of long process time. The continuous process has the advantage of speed, but is very inflexible. That is, only one type of work can be processed at a time. In most plants a variety of work is processed through the anodizers. The equipment involved for continuous production is very costly in comparison to that for the batch process. Few steps are required in the

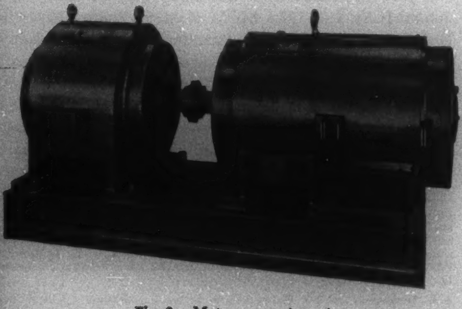

Fig. 2. Motor-generator set

Revised text of a paper presented at an AIEE Cleveland Section meeting and recommended for publication by the AIEE Committee on Chemical, Electrochemical and Electrothermal Applications.

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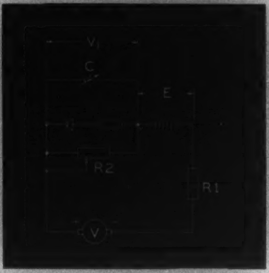

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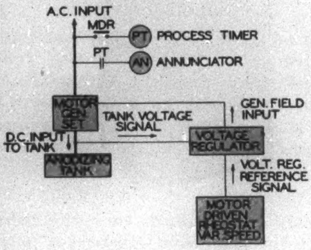
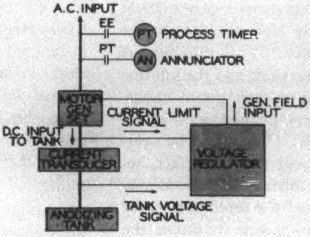
Fig. 3. Equivalent tank circuit. Fig. 4. Diagram of voltage program anodizer. Process begins with motor-driven rheostat in low reference-voltage position. Drive motor increases reference at adjustable rate to adjusted limit closing contact MDR and energizing timer. Expiration of time energizes annunciator. Fig. 5. Panel for voltage program anodizer. Fig. 6. Diagram of current limit anodizer. Process begins under current limit control. Contact EE is open. When operating voltage is reached, contact EE closes energizing timer. At expiration of time contact PT energizes annunciator


A.C. INPUT
MDR
PT
PROCESS TIMER
PT
ANNUNCIATOR
AN
MOTOR GEN SET
TANK VOLTAGE SIGNAL
GEN. FIELD INPUT
D.C. INPUT TO TANK
VOLTAGE REGULATOR
ANODIZING TANK
VOLT. REG. REFERENCE SIGNAL
MOTOR DRIVEN RHEOSTAT VAR. SPEED

4


A.C. INPUT
EE
PT
PROCESS TIMER
PT
ANNUNCIATOR
AN
MOTOR GEN SET
CURRENT LIMIT SIGNAL
GEN. FIELD INPUT
D.C. INPUT TO TANK
CURRENT TRANSDUCER
VOLTAGE REGULATOR
TANK VOLTAGE SIGNAL
ANODIZING TANK

6

5

process of anodizing and, since these steps are relatively long in comparison to the plating processes, it is generally more economically feasible to anodize aluminum by the batch process.

ELECTRIC EQUIPMENT

Power Supplies. There are two general types of power supplies normally used for anodizing. They are motor-generator sets and dry-disk rectifiers.

The rectifier and step-down transformer alone produce a constant direct voltage which is not suitable for anodizing; an explanation for this is given in the section on control. A means for varying the voltage must be provided. The variable voltage is provided most economically by means of an induction regulator and step-down transformer in conjunction with the rectifier. Fig. 1 shows curves of power factor and efficiency versus tank current of this device and a motor-generator set for comparison. The power factor is quite lagging because of the displacement of voltage from current in the induction regulator and rectifier transformer, and because of the harmonic content in the a-c line current due to the rectifier.

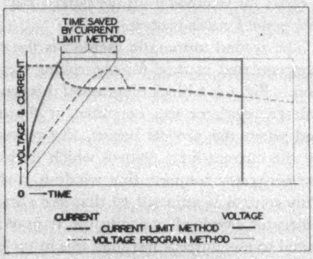


Fig. 7. Curve of process time

A second type of dry-disk-rectifier power supply consists of a series of constant-voltage rectifiers, each of which supplies a fraction of the final operating voltage to the tank. At the beginning of the initial build-up period, only one unit is in the tank circuit, and at intervals, increments of voltage are added by switching additional units into the circuit. At the end of the build-up period all of the units are connected in series, and they are supplying power to the tank.

Another rectifier method uses two or more constant-voltage tanks, each succeeding tank being of a higher voltage than the previous tank. The work is moved from the lowest voltage tank progressively to the highest voltage tank to provide the build-up period.

Rectifiers have the advantage of low initial cost, small physical size, and freedom from moving parts. They are used extensively in small installations.

The usual motor-generator set for anodizing applications consists of an induction or synchronous motor driving a shunt-wound d-c generator. A differential shunt field is often necessary to reduce the residual voltage. Line contactors between the generator and the tank are not normally provided because of their high cost for the operating currents encountered in practice. The load is applied and removed from the generator by controlling its field excitation. A motor-generator set driven by a synchronous motor has the advantage of unity or leading power factor as well as high efficiency and low maintenance. Because of their low operating cost and the other points in their favor, motor-generator sets are used extensively in the larger installations. Fig. 2 is a typical motor-generator set for this application.

Process Control. The rate of production, quality, and uniformity of product determines the type of process control required. Since batch control is more prevalent, it is discussed in preference to continuous-process control.

Before the anodizing process begins, aluminum has an extremely thin coating of oxide on its surface, about 0.5×10^{-6} inch, which offers a relatively low resistance to the flow of current through the solution. This thin film of oxide acts as a dielectric between the work and the solution in which the work is immersed thus producing tank capacity. The tank cell has a low but very definite polarization potential in the order of 1 to 2 volts. This must be overcome before appreciable current will flow. In fact, removing the entire potential after anodizing for a period may cause a slight reverse current to flow back through a power source which will permit it. As the process continues, the oxide coating increases in thickness in almost direct proportion to the product of current and time. This produces two very notable changes in the load as seen by the power supply. One of these is the formation of an aluminum-oxide rectifier in the blocking direction whose reverse to forward resistance ratio increases with ampere-hour input. The second effect is a decrease in the tank condenser capacity C with ampere-hour input due to increased spacing between the electrolyte and the anode. Fig. 3 is the equivalent tank circuit.

A simple equation can be written related to the voltage V_1 between the outer surface of the film and the anode.

$$i=(V_1/R_2)+C\,dv_1/dt$$

where

$$C=K_1(1/it) \text{ and } R_2 \approx K_2it \tag{1}$$

R_1 = electrolyte resistance and E = polarizing potential.

Current, at constant voltage, reaches a nearly steady value when equilibrium is established between the rate of formation and dissolution of the film in the electrolyte during the final stages of anodizing. The problem, then, is how to handle the changing load characteristic during the initial stages of the process.

The best solution is to reduce the starting voltage to the point where the initial current of the tank does not exceed the safe overload capacity of the power supply. As the process continued, the voltage would be increased until it reached the operating value at which time the supply would be operating near its rated output current.

In large anodizing installations, completely automatic control is used. The initial cost of this equipment is high, but it is more than offset by elimination of the human element of manual control, and thus a more uniform quality product is obtained.

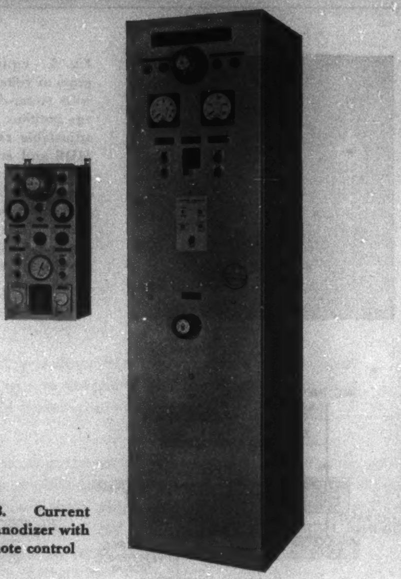


Fig. 8. Current limit anodizer with remote control

There are two automatic methods for controlling the entire process with motor-generator power supplies. The same type of control, of course, can be applied to dry-disk rectifiers as well. The first is a voltage programming method. Fig. 4 is a block diagram of a control of this type. An auxiliary relay initiates and concludes the cycle by closing and opening the generator field circuit. The motor-driven rheostat controls the reference of the voltage regulator, and thus the generator output voltage. The time for the initial increase of voltage is set by adjusting the speed of the motor-driven rheostat to meet the generator load conditions previously mentioned. When the voltage reaches the desired operating value, the rheostat arm operates a limit switch which shuts off the motor driving it, and turns on the timer. The timer, at the end of its preset cycle, completes the circuit to the annunciator, warning the operator that the process is complete and the work is ready for removal from the tank. Fig. 5 is a typical control panel for this process.

The second automatic method is the current-limit voltage-regulated method for controlling the anodizing operation. Fig. 6 is a block diagram of this type of control. The voltage regulator can be preset at the operating voltage, and when the process begins, the generator is controlled by the current-limit control which derives its signal from the generator commutating winding, a shunt, or bus flux. This control is adjusted so that the current is within safe generator overload capacity, or it may be manually adjusted to any current less than this in the event of poor contact with the work, or inadequate heat dissipation at the contact surface. With this control, the voltage of the generator will automatically reach the operating value in the minimum possible time with the power equipment available. As the current drops below the adjusted limit of current at the operating voltage, the regulator begins to control voltage at the tank and a control relay operates and completes the circuit to the timer. At the end of the preset time, the annunciator sounds warning the operator that the process is complete. This method is not only the fastest and simplest economically available, but it takes advantage of the short-time overload rating of the power supply which, in the case of most quality motor-generator sets, is 125 per cent. The current limit scheme has the additional feature of self-protection from overload which could occur from short circuits in the tank at any time during the process. Fig. 7 is a curve of voltage and current versus time for the current-limit and voltage-program methods showing the decreased process time using the current-limit method. In these curves, the current drops at the end of the build-up period. This is due to the capacity effect and increased rectifier resistance with time. The drop in current is not instantaneous because of the resistance-capacitance time constant of the tank "condenser" and the electrolyte resistance. Fig. 8 is a typical control of this type.

Instrumentation and Metering. The temperature of the solution, as previously noted, must be held to fairly close tolerances. This can be supervised with a recording thermometer. The thickness of the oxide is almost directly proportional to the product of current density and time, therefore, an ampere-hour meter will provide a direct indication of the film thickness. Of course, a recording voltmeter and ammeter will provide supervision of the program process. A pH meter is required to determine the percentage of free acid in the electrolyte solution.

SUMMARY

THE most common methods for aluminum anodizing used today are the 5- to 10-per-cent chromic-acid and the sulfuric-acid batch processes. For most large installations, the synchronous-motor-driven shunt-wound-generator power supply with automatic process control provides the best means for anodizing, while in small installations, manually controlled dry-disk rectifiers are preferable. The automatic control which utilizes to greatest advantage the power available from the supply, or the power acceptable by the work, is the current-limit voltage-regulator system. This control can be adjusted to reduce the process cycle to the absolute minimum that conditions will permit.

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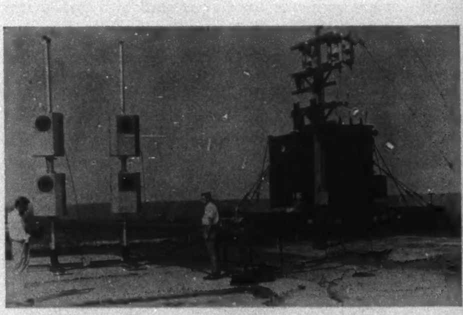
Acoustic Survey Service for Transformers

Allis-Chalmers offers a service which analyzes transformer noise from the standpoint of the environment in which the transformer will be installed. Ambient noise in the area surrounding a planned transformer site is carefully studied. This includes the effects of topography, subterannean rock formations, day–night, and other variations, as well as both measurements and recordings over the entire noise spectrum. A full complement of specially designed equipment is being used by the survey crew. These measurements can form the basis for reproducing an accurate replica of the ambient noise. An outdoor laboratory at Carrollville, Wis., with an unusually low ambient-noise level, permits a number of variations in the survey. Facilities to energize any rating of power transformer under accurately controlled conditions are available. This service is offered at nominal cost to any power company.



Allis-Chalmers engineers take sound level readings and superimpose this transformer's recorded sound level on a recorded ambient at a proposed installation site

An Electronic Blood-Count Meter

P. L. FROMMER
STUDENT MEMBER AIEE

A direct-reading blood-count meter is described which yields results independent of particle size and coloration, rate of sampling, and quantity sampled. Errors from zeroing, changing sensitivity, and changing illumination are eliminated by a grid-current ratio amplifier.

THERE is a real need in the clinical laboratory for an automatic, accurate, and inexpensive instrument capable of determining the number of red and white cells per unit volume of blood.[1] Before undertaking the discussion of the instrument that has been developed for this purpose, a clear understanding of certain physical properties of blood is necessary.

In human blood, the red cells, which are approximately disk shaped, average 0.0003 inch in diameter and 0.0001 inch in maximum thickness and have a normal count (number of particles per cubic millimeter) of 5 million; the white cells are on the order of twice as large but occur in far lower concentrations, around 7,000 per cubic millimeter. In clinical problems, the dimensions of the cells vary considerably—in a given sample there may be red cells with diameters ranging between 0.0001 and 0.0005 inch;[2] the coloration, specific gravity, and refractive index are also variables.[3] Red-cell counts may vary between 1 and 9 million, while white-cell counts may range from 1,000 to 200,000.

Because of the high initial concentrations, diluting the blood before making counts is standard practice. Red-cell counts neglect the error introduced by the presence of the comparatively few white cells; for white-cell counts, a diluent is used that destroys the red cells without affecting the white ones.

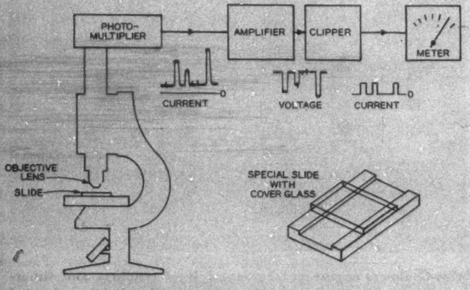


Fig. 1. Block diagram of the electronic blood-count meter

PRIOR ART

THE classical manual technique of counting blood cells consists of placing a dilute sample on a microscope slide and counting the number of cells visible on certain ruled areas on the slide. It is slow, fatiguing, and liable to human error.[4]

The earliest automatic methods, depending upon the turbidity of the sample,[5–7] have been improved so that compensation for cell size is partially achieved over the small range in which the majority of normal red cells occur.[2] Counting particles individually as they appear in a limited microscope field has been tried frequently.[8,9] The electronic scanning of a microscope field and counting the number of pulses is the most recent development,[10] but the expense of the necessary closed-loop television system is great. One embodiment of this scanning technique is the only automatic means that does not require uniform particle size for accurate results. In order to count large particles only once, this unit scans two adjacent lines of the raster simultaneously and registers a count only when there is a signal from the lower beam and none from the upper one.[11]

THE NEW TECHNIQUE

ALL the previous art has dealt with efforts to determine the total number of particles in a given volume of sample by inspecting a known quantity of solution and either counting individually the number of particles in it or by obtaining an over-all count as by measuring the light transmission. The principle of this instrument is entirely different—it is to determine the average volume of solution per single particle, which is the reciprocal of concentration.[12]

This is determined in the following manner: A very small inspection zone is observed—one so small that, as the sample passes through it, most of the time there is no particle in the zone. However, the instrument determines the fraction of time during which there is a particle in the zone. This fraction is a direct measure of the average volume per particle according to the expression:

$$\frac{\text{average volume}}{\text{particle}} = \frac{\text{volume of inspection zone} \times \text{total time of inspection}}{\text{total time particles are present}}$$

Notice that the result is independent of the quantity sampled, the length of time of sampling, and the rate at which the sample is passed through the inspection zone.

Revised text of the Best Student Prize Paper, which won the award for papers presented during the period August 1, 1953, to July 31, 1954.

P. L. Frommer, formerly at the University of Cincinnati, is now a student at Harvard Medical School, Boston, Mass.

This article was written on the basis of work done for a thesis in partial fulfillment of the requirements for the degree of electrical engineer at the University of Cincinnati, June 1954.

The writer wishes to thank R. H. Engelmann and J. C. Frommer for their valuable advice in the design of the blood-count meter and the Electric Eye Equipment Company, Danville, Ill., for furnishing the parts for this project.

THE INSTRUMENT

As shown in Fig. 1, the instrument that was constructed consists of a microscope, a photomultiplier tube viewing the microscope field, an amplifier, a clipper, and a d'Arsonval-type meter on which the concentration is read.

The diluted sample is placed upon a special microscope slide. A channel down the length of the slide permits the cover glass to enclose a constant known depth of sample. Then the inspected volume is the depth of this sample times the area viewed by the photomultiplier. Movement of the sample through the inspection zone is accomplished by manually moving the entire slide with respect to the microscope objective. Movement need not be along any particular path, nor does it have to occur at constant speed.

The microscope is dark-field illuminated; the photomultiplier tube viewing it generates current pulses during the presence of particles in the inspection zone. A grid-current ratio amplifier is used to discriminate these pulses above the "dark current" due to stray illumination. The output of this amplifier is fed to a clipper, which generates constant current during signal from the photomultiplier, and zero current otherwise. A d-c microammeter determines the average value of this pulsating current.

Note that this average current is equal to the amplitude of the pulses multiplied by the fraction of time that they are present, which is the same as the fraction of time that particles are in the inspection zone. Since it has been shown that this is a measure of volume per particle, it is possible to calibrate the microammeter in units of concentration.

Compensation must be made in the meter calibration for the random distribution of particles, which occasionally results in the simultaneous presence of more than one particle within the inspection zone. This is a simple problem in the mathematics of probability. Also, to assure accuracy, the width of the inspection zone is made great in comparison to particle width so that the signal rise time, which is dependent upon particle size, is small relative to the total time of the signal.

OPTICS

The optics of the instrument were built around a standard microscope, as shown in Fig. 2. In order to obtain sharp contrast between the signal from a particle and the background, dark-field illumination is employed. This means that the field seen through the microscope appears black and any particle in the field shows up as a point of light. This is done very simply on any microscope by placing a mask in front of the center of the condenser lens, thus permitting only those beams of light to illuminate the slide that will not pass directly into the objective lens. However, any particle on the slide will cause dispersion of the light falling upon it and some of this dispersed light will fall upon the objective, which directs it to the photomultiplier.

The field inspected by the photomultiplier is limited by a mask in the plane to which the objective normally focuses the slide. This permits the microscope to be brought to focus by the regular eyepiece, which is then removed and replaced by the phototube chamber and its mask.

To avoid 120-cycle noise, the slide is illuminated by a lamp fed by half-wave rectified resistance-capacitance filtered direct current. Provision must be made to shield the microscope from intense stray illumination such as direct sunlight.

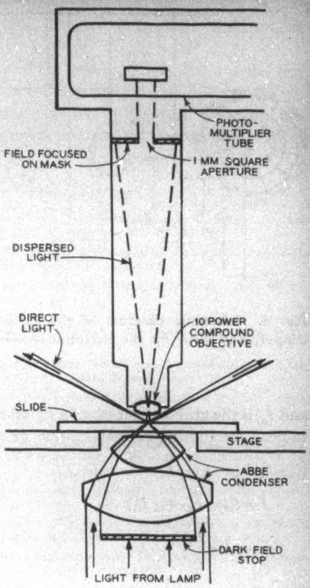


Fig. 2. Optical system for the meter

THE AMPLIFIER

The very small amount of light dispersed by a single blood cell requires a highly sensitive detector, so a photomultiplier is a natural choice. But the sensitivity of a photomultiplier varies greatly both with time and with applied voltage. For instance, 1-per-cent change in applied voltage may cause a 20-per-cent change in output current. There are also such variations in the optical system as lamp brightness and microscope adjustments. However, experience has shown that a signal to dark-current ratio of 2:1 and a signal to noise ratio of 5:1 is approximately maintained. Thus the best method of determining a signal is by comparing it to the dark current, not to an absolute value. The grid-current ratio amplifier accomplishes this and thereby completely eliminates the sensitivity adjustments and dark-current nulling commonly encountered in sensitive phototube circuits.[13] This is accomplished according to the following theory:

Because of the Maxwell distribution of velocity of electrons emitted by the cathode, if grid current flows in a tube the grid will assume a voltage[14]

$$V_c = a + b \log I_c$$

where a and b are constants.

Then if I_{c1} is the grid current due to stray illumination

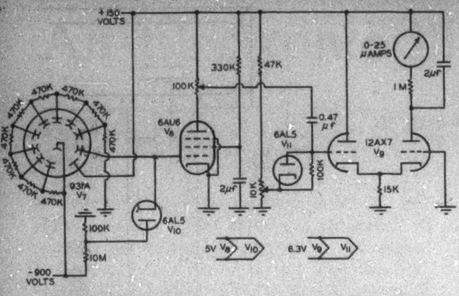

+150 VOLTS
0-25 μAMPS
2μf
1M
330K
47K
100K
470K
470K
470K
470K
470K
470K
470K
470K
470K
0.47 μf
6AU6 V8
6AL5 V11
12AX7 V9
2μf
10K
100K
15K
931A V7
100K
6AL5 V10
10M
-900 VOLTS
5V V8 V10
6.3V V9 V11

Fig. 3. Schematic diagram of the photomultiplier, amplifier, clipper, and meter for the electronic blood-count meter

and I_{c2} is the grid current when a signal is present, the peak-to-peak alternating voltage on the grid will be

$$
\begin{aligned}
V_{c2}-V_{c1} &= (a+b\log I_{c2})-(a+b\log I_{c1})\\
&= b(\log I_{c2}-\log I_{c1})\\
&= b\log\frac{I_{c2}}{I_{c1}}
\end{aligned}
$$

Then, assuming linear operation, the peak-to-peak alternating voltage on the plate will be

$$E_{b2}-E_{b1}=c\log\frac{I_{c2}}{I_{c1}}$$

where c is a constant.

Note that the output of this grid-current ratio amplifier is proportional to the ratio of signal to dark current, not to the absolute value of the signal amplitude. This has been verified experimentally by varying the voltage to the photomultiplier from −670 to −1,200 volts, which varies the sensitivity by a factor of 100, with the output of the grid-current ratio amplifier remaining constant within 3 per cent. In other applications, this grid-current principle has been found useful for grid currents in the range from 10^{-3} to 10^{-9} ampere.

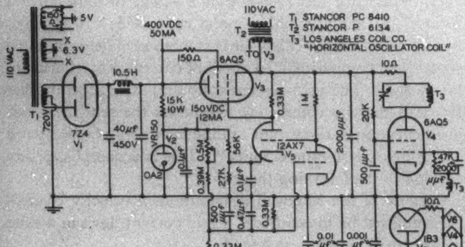

110VAC
5V
150 Ω
X
6.3V
X
T1
720V
7Z4 V1
10.5H
40μf 450V
400VDC 50MA
150Ω
15K 10W
150VDC 12MA
VR150 V2
OA2
0.1μf
0.39M
0.5M
27K
56K
0.1μf
6AQ5
V3
110VAC
T2
TO V3
T1 STANCOR PC 8410
T2 STANCOR P 6134
T3 LOS ANGELES COIL CO. "HORIZONTAL OSCILLATOR COIL"
0.33M
1M
12AX7 V5
2000μμf
20K
500μμf
10Ω
T3
6AQ5 V4
47K
2000 μμf
T3
10Ω
1B3 V6
T3
V6
V4
V1
6.3V
500 μμf
0.47μf
0.33M
0.33M
3.3M 1W
0.01 μf 1250V
0.001 μf 2500V
10K
10K
-650 TO -1350 VDC 1.35MA

Fig. 4. Power supply for the electronic blood-count meter

As shown in the schematic diagram of Fig. 3, the photocathode of the photomultiplier is given a high negative voltage, such as −900 volts. Nine dividing resistors to ground provide proper voltages for the first eight dynodes, the eighth dynode in this case assuming a potential of −100 volts. The plate is brought to +150 volts; the ninth dynode is connected directly to the grid of the ratio amplifier. Such a connection is necessary because the ratio amplifier requires current flowing into its grid. The floating ninth dynode with respect to the rest of the photomultiplier is done so that the rest of the photomultiplier and the high voltage may be definitely referenced to ground. With the circuit used, the current to the grid of the ratio amplifier is the difference between the plate current of the photomultiplier and the current between the last two dynodes.

In addition to the stable operating point thus described, there is a stable condition in which the ninth dynode assumes a potential slightly more negative than the eighth dynode. Under these conditions, grid current to the ratio amplifier is completely cut off due to its highly negative grid and the plate current of the photomultiplier is cut off for lack of secondary emission. Between these two points of stable equilibrium, there is a point of unstable equilibrium at which the secondary emission of the ninth dynode exactly equals the current reaching it from the eighth dynode. The undesirable stable condition is prevented by connecting the ninth dynode to the cathode of a diode, the plate of which is maintained around −10 volts.

The operation of the grid-current ratio amplifier has already been discussed. The signal from its load resistor is capacitor coupled to the first triode of the clipper stage where a diode provides d-c restoration. This grid is given a positive potential with respect to ground so that cathode-follower action in this triode develops sufficient voltage across the common cathode resistor so that the grounded grid triode is kept cut off in the absence of signal. The signals to the first triode, which are all negative pulses, are of sufficient amplitude to drive that tube to cutoff, permitting current pulses of constant amplitude in the second triode. The capacitor from $B+$ to the plate of this triode causes the load resistor and the series microammeter to be affected only by the average plate current, that is, the average value of the current pulses. Thus the microammeter reads the fraction of time that a signal is present according to the expression

$$I_{\text{ave}}=I_{\max}\frac{\text{total time signals are present}}{\text{total time}}$$

$I_{\max}$ is made, say, five times the current required for full-scale deflection on the microammeter, so that if particles are present one fifth of the time, full-scale deflection will result. If $I_{\max}$ were made many times the current required for full-scale deflection, scale changes could be accomplished by switching to appropriate meter shunts. In any case, going back to the optical system, a different objective lens or a different mask could be used to change the inspected volume and thereby change the scale.

It should be noted that since the load resistor of the last triode acts only upon the average current, the plate voltage will be that corresponding to the average plate current. Since the amplitude of the current pulses is slightly dependent upon the plate voltage, compensation must be made in the meter scale for the slight decrease in current pulse amplitude when current pulses occur for a greater fraction of time.

In practice, the first triode of the clipper must be given sufficient positive bias that the amplified Johnson noise from the photomultiplier will not permit conduction in the second triode. Also, the amplitude of the signal coupled from the ratio amplifier must be adjusted so that the proper portion of the signal pulse is clipped out by the clipper stage.

THE POWER SUPPLY

The schematic diagram of Fig. 4 shows a conventional full-wave condenser-input filtered-$B+$ supply capable of delivering 400 volts with a 100-milliampere current drain. This is far more power than is necessary, for only 20 milliamperes is used for the voltage-regulator tube, regulated 150 volts, and 25 milliamperes is used for the regulated -650- to $-1{,}350$-volt 1.35-milliampere supply. This high voltage is the triple resistor-capacitor filtered half-wave rectified output of a tickler coil r-f high-voltage oscillator. Regulation is achieved by controlling the $B+$ to the oscillator through a series tube, the grid of which is controlled by the amplified voltage appearing between ground and the reference tap on the voltage divider going between the regulated $+150$ volts and the negative output. The output may be varied by adjusting the variable resistor in the upper arm of this divider. Regulation is maintained within 0.2 per cent from zero to full load (1-megohm load) at any output voltage.

An r-f oscillator high-voltage supply was chosen because of the low-ripple output possible with low-capacitance filtering and the resulting safety to life, as well as for its adaptability to regulation. However, with the amplifier that has been developed, regulation of the high voltage is probably unnecessary.

CONCLUSIONS

The instrument that has been constructed appears to meet the requirements for a useful particle-concentration meter.

1. Simplicity of operation requires the technician to move a slide under the microscope objective and to read the blood count directly from the deflection of a meter needle—there are no zeroes to set, nulls to balance, or size compensation factors to apply. White-cell counts may be taken by using a smaller dilution and reading the meter on a different scale.
2. Low cost is inherent in a system that requires only a 5-tube amplifier and a 6-tube power supply, all using only standard inexpensive components. There are no optical or mechanical parts not already found on all standard microscopes, except the slide, the phototube housing, and the light mask. The whole instrument may be considered a microscope accessory.
3. The accuracy of the instrument has not been tested, but there appear to be no inherently inaccurate parts in the electronics, while the optics in combination with the electronics have the advantage of yielding results substantially independent of particle size and coloration, and rate of sampling.
4. The versatility of the instrument makes it useful not only for both red- and white-cell counts, but for microscopic-particle counts in general—for dust and plankton counts, and for impurity and colloid counts in chemical solutions.

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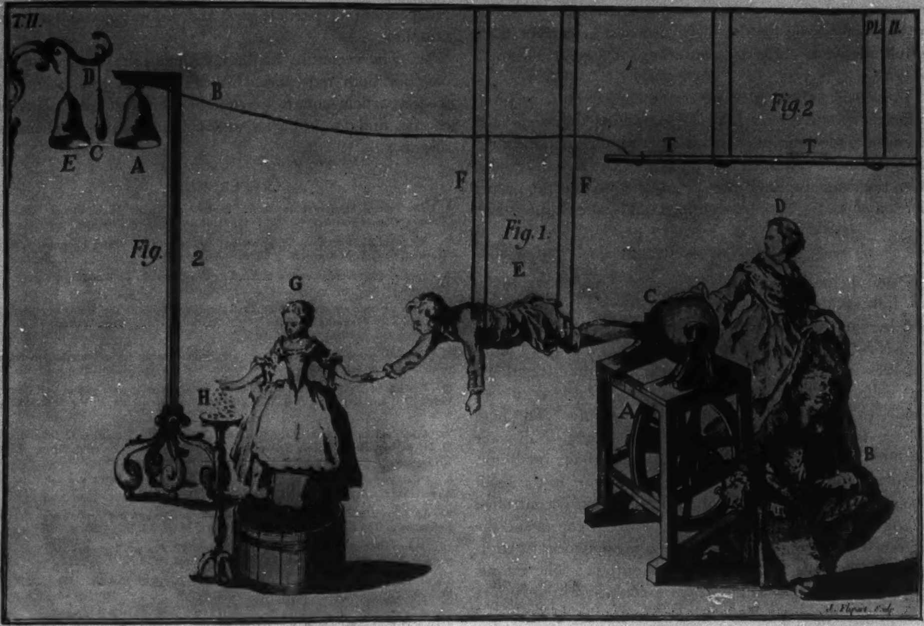
Miniature Transistor Preamplifier

DuMont transistor preamplifier can amplify 1,000 times electric signals of a millionth of a volt and power of a billionth of a watt



Rotary generator and human capacitance in the early 1740's

The Electrical Flare
of the 1740's

LLOYD ESPENSCHIED
FELLOW AIEE

FROM TIME IMMEMORIAL man must have been conscious of gentle mysterious attractions which accompanied the rubbing of certain surfaces. Then, in a single decade of the 1700's, there was awakened from its long sleep what proved to be a giant bent on dealing startling shocks and bolts of fire. This awakening was part of the most dramatic and portentous wave of advance in the entire annals of electricity, to be matched in public participation only by the fireworks attending modern radio, electronics, and atomic fission.

The following is an example of the accounts of the time taken from a British periodical of 1745,[1] "An historical account of the wonderful discoveries, made in Germany, etc., concerning Electricity." After citing yet earlier discoveries, the article reports that the German naturalists "...then took the subject under examination. And from the year 1743 they discover'd phenomena, so surprising as to awaken the indolent curiosity of the public, the ladies and people of quality, who never regard natural philosophy but when it works miracles. Electricity became all the subject in vogue, princes were willing to see this new fire which man produced from himself, and which did not descend from heaven. Could one believe that a lady's finger, that her whale-bone petticoat, should send forth flashes of true lightning, and that such charming lips could set on fire a house? The ladies... resorted from all parts to the public lectures of natural philosophy, which by that means became brilliant assemblies."

Less brilliant as an assembly, perhaps, but again reveal-

Important and little-known information about the progress made in electrical science during the decade of the 1740's is presented. Emphasis is placed on the German contributions in that period.

ing of the times, was a classroom at Harvard in colonial New England, in the course of which the professor[2] echoed the European excitement in these words of 1746:

> "...this Electricity since the year 1743 has made a considerable noise in the World."

The noise was actual, in the sparks, and figurative in the mind. What follows is an attempt at tracing and interpreting the tide of advance that was causing it, in the light of modern understanding; although it must be admitted that the physics of surface or contact electricity has not yet been mastered. To ascertain what went on, one must consult the original literature, difficult as it is to find, for the experiments were not adequately reported by later writers. Electrostatic electricity was a technique of extremely high impedance characterized by discharges in air and in vacua, an understanding of which has been greatly aided by the modern technology of radio and electronics.

PRECEDING KNOWLEDGE

NATURALLY, the interest in the world concerning electricity had not arisen out of thin air, but rather from the solid base of previous experience. This had been in the realm of weak manifestations, but established recognition of electrical conduction and insulation—the fact that some bodies convey electricity and some do not—and that those which do not can be used to prevent escape from those which do. This combination of the conductor and insulator must have been experienced for millenia in one way and another. It occurs in the commonly experienced case of a person scuffing across a rug and planting a spark on the nose of a friend. In such an instance several actions are recognized today: generation of the charge in the shoe—rug contacts; passing of it to the conducting body; provision of insulation-to-ground in the rug; and the accumulation of the successive scuff-charges in the body is appreciated by virtue of its capacity to ground. In many such mechanical actions the human body must have constituted man's first condenser (capacitor) as well as generating mechanism, but the "tumbling" to the situation was a long time coming. It came about as, in the course of groping trial, man separated the two functions of generation and conduction to another body. The two most immediately concerned in so doing were Stephen Gray, an ingenious "Poor Brother" in England, and Charles François du Fay, chief of the Royal Botanical Garden, Paris, France, a broad-gauged natural scientist.

Back in the mid-1600's Otto von Guericke, he of the vacuum pump and the Magdeburg evacuated spheres for demonstrating atmospheric pressure, reported having observed the extension of the electrical influence over a string a few feet long. In the 1720's, starting anew, Gray demonstrated transmissions over highly insulated cords up to several hundred feet long. He communicated the charge also to a boy suspended on silk cords, perhaps the first deliberate use of the human body as a conductor separate from the generating function. The effects were weak and he employed for detection the attraction of light bits of material. His experiments appeared in the *Philosophical Transactions* of the Royal Society of London.[3]

Taking up from Gray, du Fay carried on with better experimental facilities and covered a wider range of conditions. The use of the human being as a "live" conductor was quite in keeping with the "grand manner" experimentation of the time, and he permitted himself to be the suspended being. Thus he experienced from within, as it were, the cobweb hair-raising sensations and the prickly discharges which he likened to fire. His electrification may have been more intense than Gray's, with whom he was in communication, and probably the climate more dry, for he increased the distance of transmission over a cord to over 1,000 feet. Finally he made the capital observation that a charge produced on a vitreous or glasslike surface and that produced on a resinous or amber surface had opposite effects. This led to the recognition of the fundamentally dual nature of electricity, what is now called plus and minus.[4]

The state of knowledge immediately following these pioneers, constituting the base of the advance of interest here, is well indicated in an essay on electricity written in 1742 by Dr. Joseph Desaguiliers which won a prize. It was he who contributed the word "conductor" and the counter term "nonconductor," and promoted appreciation of the cooperative combination of the two classes of material. Of the action of an insulated metal bar in accumulating a charge from a rubbed glass tube, he says:

> "The Bar gives accumulated Effluvia of the Electricity which it receiv'd from all its Length, and from the Tube at several applications."[5]

Throughout the experiments of Gray and du Fay, and the teaching of Desaguiliers, the generator employed continued to be the time-honored rod of dielectric, successively rubbed and presented to the metal charge-collector. The generation and transference thereto was spasmodic and the quantity of electricity collected small. Yet the advance was fundamental and formed the base for the spectacular chain reaction that was to follow.

SPARKING OF THE FLARE

SCIENTIFIC CURIOSITY being international, the German professors then assayed the subject. They soon set off a period of feverish enthusiasm reflected in the passage quoted earlier from the English periodical. The one who sparked the new developments, starting about 1740, was George Matthias Bose, professor of natural philosophy at

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Revised text of a conference paper presented at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954.

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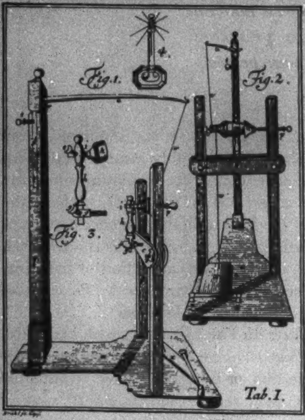

Fig. 1. Speeded-up self-contained generator, 1744

the University of Wittenberg. Contemporary with him was Christian August Hausen, professor of mathematics at Leipzig. Both men in their fresh approach were dissatisfied with the limitations of the rubbed glass tube and sought to strengthen the generating action. Each, apparently independently, harked back to a rotated glass globe that had been experimented with by Francis Hauksbee several decades earlier. Hauksbee's machine comprised a hollow glass globe mounted on a spindle, belt-driven lathelike from a hand-cranked wheel. The charge was generated by rotating the globe against the friction of the palm of the hand as Otto von Guericke had done long before using a sulphur globe. Hauksbee's approach had been to study the mysterious glow that long had been observed in a Torricelli vacuum upon agitation of the mercury column. Hence Hauksbee had used an evacuated rotating globe, and as he applied hand friction concentrated attention on the glow discharge within. He was not moved to lead the charge off into a conductor as Gray did soon after, but employed only the rubbed rod.

Thus the adoption by the Germans of the Guericke-Hauksbee rotary generator, in combination with the large conducting body employed by Gray and du Fay, amounted to a new system as was soon demonstrated by magnified effects. The consequences were of a new order of magnitude because continuous generation kept the conductor, a capacitor, stored full and the level was higher than before by virtue of the faster rubbing effected. The enhanced effect was analogous to that experienced in early radio in going from the discontinuous spark transmitter to the continuous-wave generator. A disconcerting result reported to have been found by Bose was

"...that the kisses of a lady placed on the pitch" (insulation) "and electrified with the globe of glass, were as irksome as wounds by the pain which they caused. This gallant experiment he relates in a manner as if he would have us believe that he thought himself sufficiently pay'd for the smart which he suffered; but for all that he durst not renew his kisses more than three times."[8]

A more awe-inspiring outcome was the striking of fire electrically, this through the intermediary of a highly inflammable substance such as gunpowder or a spirituous drink. What is more, the fire came from the tip of one's finger. Even from the surface of water, hot sparks could be drawn. The excitement was the greater because fire was then regarded as one of the four fundamental elements of the universe, which added to the mystery of, and respect for, the new force. This so-called "phlogistic" or "flammific quality with which the electric globe endues animals and metals,"[7] seems to have been discovered not only by Bose but also by Ludolf of Berlin and Gralath and Hanou of Danzig, an example of how inevitable are the consequences of a new combination, continuous generator plus storing capacitor.

A typical experimental setup of the time is shown in title picture. This appeared in a 1752 French translation of William Watson's "Sequel to the Experiments..." dated 1746, but is a good representation of the generating system used by Bose, Hausen, and others in Germany somewhat earlier. The person on the far right (*B*) provides the motive power. The woman (*D*) applies by hand friction to the rotating globe. The boy (*E*) in the center, who appears to be swimming, is highly insulated from ground by being suspended on silk cords. His feet in close proximity to the globe take off the charge which permeates his body, storing therein the charge. He communicates the charge to the girl (*G*) standing on a tub of insulating pitch, who thus adds to the storage capacity of the system; between them they provide a high-impedance load which more or less matches the high internal impedance of the frictional generator. Above to the right is an inanimate form of capacitance, a fair-sized metal rod or tube, highly insulated on cords, which was coming to be called the "prime conductor." Here, it is not connected to the generator. To the upper left are bells which are rung electrically through the action of the dielectric clapper *C* in being alternately attracted to and repelled from the bell *A* when charged (invented by Andrew Gordon). Altogether, this was a spectacular laboratory technique revealing the ingenuity and spirit of experimentation of the period.

By 1743 Bose and Hausen each published a work in Latin. The frontispiece of the Hausen brochure is a forerunner of the above and appears to be the first illustration of the vital combination of the day—the rotating generator linked to capacitance in the form of the human body. The latter, however, was still being generally regarded as simply a conductor. Bose published in Germany three Latin treatises by 1743, and the following year reprinted them with an addition. One of the three was a poem, the first to sing the praises of electricity, and one of the themes therein was so-called "beautification" of the human being. This was the most mysterious of his staged effects. A halo glow, such as surrounds the head in old religious paintings, was produced electrically about a living person. The trick turned out to be this: Concealed by clothing, the person wore a coat of armor provided with an array of points which produced corona discharges. The British, who were then having difficulty in repeating the German demonstrations, probably because of their damp climate, were particularly puzzled over this one, and gave no evidence of appreciating it even when the secret was "declassified" by its author.

By 1744 the German work was being reported in the *Philosophical Transactions* of the Royal Society, through letters written by Bose himself, by Heinrich Winkler, professor of Greek and Latin at Leipzig, and by Samuel Christian Hollmann, professor at Göttingen. Included were improvements being made in the generating machines. Winkler had undertaken to make the machine smaller and simpler to handle, by using a smaller rotor sped up by means of a foot pedal, and by replacing the hand application of friction, which required a second person, by a cushion made part of the machine. One of the early Winkler machines is shown in Fig. 1, taken from his 1744 book, the first of three in as many years.[8] Hollmann made two improvements: one, a more accurate mounting of the glass globe on its axis permitting higher speeds;[9] the other, a better take-off of the charge into the prime conductor, comprising tinsel threads affixed to the conductor and engaging the surface of the rotating sphere without danger of harsh contact.[10]

Something of the state of the art as of 1745 is illustrated in Fig. 2, taken from Winkler's second book. The interesting machine on the left unites in parallel into a common prime conductor (shown vertically in the middle) eight rotors of cylindrical form disposed in two groups. Each group is provided with a rack of friction pads shown at sub *Fig. 8*, all spindles being driven by belt from the large wheel. In the machine at the lower right, sub *Fig. 9*, the rotors are disposed with their axes vertical, a rubbing pad being indicated at the right, *g*. Above, right, are various forms of brush discharges from points, in air and in vacua. Near them is a multiple bell arrangement mounted on a circular base. Winkler's care in trying to formulate the principles underlying his studies is well illustrated by his statement of the mutual relation that exists between dielectric and conducting materials. In a section entitled "The Strengthening of Electric Sparks," he says:

"The smaller the supporting substance (dielectric) of an electrified (conducting) body, the more its electricity increases and propagates, the stronger are the electric sparks.

"In the same way, the electric sparks are strengthened when one increases the mass or matter of an electrified (conducting) body."

DISCOVERY OF THE CONDENSER

A GREAT INCREMENT to the flare was to occur in the discovery of the actual electric condenser, in the form of the Leyden jar, during 1745–46. Priestley called it "the most surprising discovery that has yet been made in the whole business of electricity."[11] In principle the condenser already had been discovered in the capacity of large conduction bodies to accumulate electricity; but principles are after-the-fact generalizations. Such a radically different form of thing as a condensed condenser remained to be found the hard way, by experimental accident.

Inevitable it was in the spreading experimentation, involving the leading of electricity into all manner of materials and vessels, that someone would electrify a conducting insulated substance lying close to another conducting area not insulated. Probably the first encountering of this condition, which was to manifest itself by an enhanced spark, will never be known. But two experimenters who came upon it independently and almost simultaneously, and recognized the signal, are known.

The earlier was the dean and prelate of the Cathedral of Camin near Danzig in Pomerania, von Kleist in October 1745. He found that if a conductor is inserted within a glass tube, then when the tube is rubbed, sparks can be obtained from the conductor. (Presumably the hand doing the rubbing supplied the outside grounded conductor.) Next he found that if one takes a narrow-necked vial, inserts in it the conductor in the form of a nail, grasps the vial, and presents it to an electrifying machine; then, upon withdrawing, a flame follows, especially if the inside conductor is accompanied by a liquid. Here the nail and liquid provided the inner coating and the grasping hand the outer coating of the condenser. But imagine how puzzling the circumstances. Von Kleist reported that the shock given by a vial only 4 inches in diameter, containing liquid, was so strong that no man would care to repeat it, and added that Bose would never dare brave the kiss of a Venus so armed.[12,13]

Thus it was found that electricity could be bottled. Holding the bottle in the hand seemed crucial. Since von Kleist had "backed into" the discovery through devious conditions, the description given his acquaintances was abstruse and unorthodox. His reports[14] were incredulously received, and it was not until February 1746 that one correspondent reproduced the effect. This was Daniel Gralath, and he appears not to have written a confirming letter until April 10, 1746.

Meanwhile Dutch experimenters at the University of Leyden, headed by the famous natural philosopher Peter van Musschenbroeck, made the same discovery. In January 1746 from Leyden he described his startling experience to Reaumer in Paris, in a letter which began:

"I wish to inform you of a new, but terrible experiment,

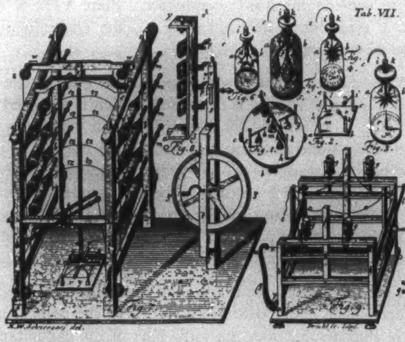

Fig. 2. Multirotor generators: point brush discharges, 1745

which I advise you on no account personally to attempt." He describes the stroke received, saying: ". . . . I believed I was done for."

The letter was made public by Abbe Nollet,[15] and through it knowledge of the discovery became public in France and England, and hence the name Leyden jar. Winkler wrote a letter to the London Royal Society of his own test of the experiment, reporting convulsive shocks administered to himself and his wife, while averring it wrong to inflict such pain on a bird as the Berliners had done.[16] His book dated September 6, 1746, was perhaps the earliest on the subject by one in touch with both discoverers and reported their respective work. There are indications that Winkler himself had been among those who had not understood and not responded to von Kleist's early reports. Singularly enough, the title of Winkler's book is about as unintelligible today as were von Kleist's initial letters on the subject. The queer title, plus the extreme rarity of the book, probably accounts for its remaining almost unknown.[8] The title of the book concerns water because that was the liquid used to provide the inside conductor. Plate VIII of the book is reproduced herein as Fig. 3, the corresponding explanation being:

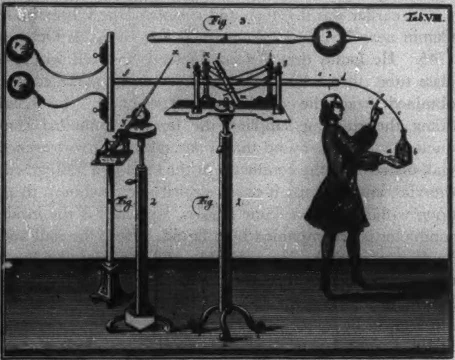
Tab.VIII.
Fig. 3.
Fig. 2
Fig. 1

Fig. 3. Discovery of the Leyden jar, 1745–46

"When a person holds with one hand a glass bottle in which a metallic wire *cd* is immersed, which is attached to a metallic tube fastened by silk cords to four columns *g*, *h*, *i*, and *k* of a stand *r*, *s*, *t*, and *u*; and with a finger *n* of the other hand approaches to a certain distance of wire *cd* while it is electrified by means of the glass globes, *p* and *q*; then there extends from the finger a painful spark which jolts the body of the person."[8-c, pp. 1–2] (The glass globes *p* and *q* generate in parallel to ground.)

From the very beginning the human body has entered into the mechanism of electrification; but here the body is not part of that action, does not form part of the capacitance as such, but does complete the condenser circuit. The path of discharge shown in Fig. 3 appears to be the first disclosure of a discrete circuit. Musschenbroeck went further than did von Kleist by finding he need not hold the bottle. He put it down on a metal plate lying on a table and charged it as before. Then by touching the plate with one hand and bringing a finger of the other hand to the charging wire, the spark and jolt occurred.

Seeking still more violent discharges, a wide range of variations must have been explored by the many attracted to the great indoor sport of the time. Soon Winkler was fattening the spark by connecting jars in parallel, which is illustrated in Plate IX of his 1746 book. The effect of the height of water in the jar was observed. Then the metal pan on which it stood was in effect extended up the side by coating the jar with lead foil. This was done by Dr. John Bevis. He also coated both sides of a thin pane of glass, thereby devising the plate condenser. He then suggested metal-coating the inside of the jar, whereby the water was replaced. By the end of the notable year 1746, the experimentation, as rounded out by William Watson and Benjamin Wilson, had revealed the power of the jar to be proportional to the area of the coating and to the thinness of the glass.[17,18] All this gave rise to the belief that glass possessed a property that made it essential to the storage action. This was to be rudely shattered in the following decade by the demonstration of the air condenser by Aepinus.[19] The storage of a charge had started in the first place in the air capacitance-to-ground of insulated bodies, as seen earlier; yet the air-dielectric condenser had to be reinvented following the intervention of glass. Recognition of the dielectric constant of glass and other material came much later.

This, then, is the genesis of the electric condenser, an evolution of experimental discovery and invention. Naturally, the appearance of the dramatic new tool widened the following of the new art. "Then, and not until then, the study of electricity became general, . . ." observed Cavello.[20] That study carried on through the latter half of the 18th century and led to the next great wave of advance, the radically new kind of electricity, of the chemical battery and electromagnetism—a low-impedance technique more amenable to practical applications.

LEVEL OF ATTAINMENT

Only the flaring advance that marked this one decade of the 1740's is considered here. The level to which it carried is higher than is generally realized. The voluminous literature to which it gave rise abounds with thoughts as to the nature of the mysterious fluid and what might be done with it. These ideas may be summarized, as of 1750, as follows:

1. Electricity had come to be regarded as a universal imponderable fluid "present in all bodies" . . . . "tends to an equilibrium, and endeavors to occupy those spaces in bodies which have not their necessary quantity, . . ." according to Abbe Nollet.[21] The conception of a surplus and deficit of the medium had developed, and soon thereafter came the plus and minus version. Attempts at measuring the strength of discharges began; the law of decay of in-

fluence with distance; the time of propagation—all evidences of electricity becoming a science.

2. The distinction between the heavy disruptive discharge obtained from smooth rounded electrodes and the more silent brush or corona discharge from pointed conductors was well recognized. Bose had called them respectively the male and female fire.[1] Something of the effect of points, even of highly heating a discharge electrode (thermionic emission), in dissipating a charge had been observed by du Fay, Winkler, and others.

3. The similarity of the electric spark to lightning had grown in recognition through the first half of the 18th century, in keeping with the strengthening of sparks, and became a conviction as the powerful discharge of the Leyden jar was realized. Winkler in his 1746 book on the Leyden jar discusses convincingly the identity; treats of the formation of charged clouds from evaporation; concludes: "...the electric sparks which are produced artificially are of the same kind as lightning and thunder in regard to matter and nature of origin...."[8-c] Wrote Abbe Nollet in 1748: "If anyone should take upon himself to prove from a well-conducted comparison of phenomena, that thunder is in the hands of nature what electricity is in ours...; if it is to be demonstrated that a cloud...is opposite to a terrestrial object;...this idea...would give me a great deal of pleasure..."[22] There followed Benjamin Franklin's famous proposal to detect cloud electrification by means of an elevated conductor, the carrying out of which occurred in France early in the next decade.

4. Propagation: The distance of transmission had been increased over the years from a few feet in the mid 1600's by von Guericke to some hundreds of feet in the 1720's by Gray, to a thousand-odd feet in the 1730's by du Fay; to the same order in the 1740's by Winkler using better defined ground return. The propagation appeared to be instantaneous. In his 1744 book, Winkler asked the question: How far can Electricity be Propagated? and answered "...the inference could be drawn that electricity could be propagated to the ends of the earth, and would be noticeable."

When he came to his "Basic Outline," 1750,[8-d] Winkler was emboldened to say that:

"...by means of electricity, one can bring about an action at any specified time, over a distance as great as can be desired on earth, such as the firing of a gun, or the giving of a signal." (p. 15)

5. Electrical applications, other than transmission, suggested in Winkler's "Outline" include its use to explain some remarkable phenomena of nature such as lightning and St. Elmo's fire; in making new discoveries in medical science; and as mental enlightenment and entertainment, in respect to some eight effects mentioned, including optical experiments with electric rays and electric rays in vacuous space.

From all of which the flare of the 1740's is seen to have been a progressive feedback between physical advance and mental flair, a dynamic prologue to the future, as is, indeed, the present electron-wave age.

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3. Reference to the Gray papers is given in a footnote of reference 1, and more completely in Park Benjamin's: "The Intellectual Rise in Electricity," 1895, p. 471, where appears a more complete account of Gray's experiments, including those in transmitting the electrical effect to about 600 feet. Additional information on Stephen Gray is noted in two articles in *Isis*, May 1954, vol. 45, pt. 1, no. 139.

4. Du Fay's papers before the Royal Academy of Paris appear in the *Histoire* for the years 1733, 1734, 1737.

5. A Dissertation Concerning Electricity, **J. T. Desaguliers.** London, England, 1742, pp. 33–4.

6. Reference 1, p. 196.

7. *Ibid.*

8. The three books by Johann Heinrich Winkler, professor of Greek and Latin at Leipzig, are
(*a*) Gedanken von den Eigenschaften, Wirkungen und Ursachen der Electricität (Thoughts on the Properties, Effects and Causes of Electricity), Leipzig, Germany, 1744. Abstracted in *Philosophical Transactions*, London, England, vol. 43, 1744–45, no. 474, p. 166; no. 475, p. 307.
(*b*) Die Eigenschaften der electrischen Materie und des electrischen Feuers aus verschiedenen neuen Versuchen erkläret, und nebst etlichen neuen Maschinen zum Electrisiren (The Properties of Electrical Matter and the Electrical Fire explained by various Experiments, and also some new Machines for Electrification), Leipzig, Germany, 1745. (There was published in Paris, France, 1748, a French translation of Winkler's first book above, combined with the second.) Something of these texts appeared also in the *Philosophical Transactions*.
(*c*) Die Stärke der Electrischen Kraft des Wassers in Gläseren Gefässen, welche durch den Musschenbrökischen Versuch bekannt geworden (The Strength of the Electric Force of the Water in Glass Vessels, which has become known through the experiment of Musschenbroek). Leipzig, Germany, 1746. Meaning the Leyden jar; inner electrode being supplied by water.
These three rare books are found in one cover in the Engineering Societies Library, New York, N. Y., and with them is bound a masterly summary of the subject, including references to the three aforesaid books, undated, but placed by Poggendorf at probably 1750. It is entitled:
(*d*) Grundrisz zu einer Ausfuhrlischen Abhandlung von der Electricität (Basic Outline for a Comprehensive Treatise of Electricity).

9. In a supplement to a German translation of du Fay's electrical works, dated Erfurth, 1745, Hollmann is referred to as having "done no small service" in mounting hollow glass spheres.

10. Hollmann's tinsel for picking up the charge is mentioned in a letter of his: *Philosophical Transactions*, London, England, January 1744–45, no. 475, p. 239.

11. The History and Present State of Electricity, **Joseph Priestley.** London, England, 1767, pp. 81, 84. His knowledge of the German developments seems to have been limited to what at the time had been put into English, for of the list of book references given at the end of his History, he reveals that most of the German works he knew not nor of the existence of some. No wonder there is no mention of von Kleist relative to the discovery of the Leyden jar. It is from Priestley that much of the subsequent English-language history of electricity has been written.

12. The Intellectual Rise in Electricity, **Park Benjamin.** London, England, 1895, p. 513. According to Benjamin, this is von Kleist's own story, presumably from letters he wrote at the time, something of which appeared in reference 14 below. There is indication of von Kleist having found the enhanced discharge by the summer of 1745 and communicated it, with insufficient understanding, to Winkler, for there is reference to such in the latter's book of that year which bears date of August 20 (present reference 8*b*). This point is given by Benjamin, p. 515, footnote.

13. Geschichte der Erde (History of the Earth), **Johann Gottlob Krüger.** Halle, 1746.

14. The letters von Kleist sent are enumerated in Winkler's 1746 book, reference 8*b*, opening chapter.

15. Musschenbroeck's letter appeared in: Memoire de l'Academie des Sciences, Paris, France, 1746; and *Philosophical Transactions*, paper no. 476, p. 419.

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Anechoic Chamber for Noise Tests on Transformers

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THE transformer noise problem has for various reasons become increasingly important and both users and manufacturers of power transformers have devoted considerable time and effort to its investigation. In 1954, the General Electric Company added a $\$1^{1}/_{2}$-million sound laboratory to its facilities. This laboratory has been designed to achieve maximum accuracy in transformer noise measurements for both developmental and acceptance tests.

There are two important requirements which must be fulfilled by the space in which noise measurements are made if accuracy is to be obtained. First, the ambient noise must be low enough to keep it from contributing appreciably to the readings, and second, the reflection of sound from walls or nearby objects must be controlled to prevent excessive errors.

The test area of the laboratory has an ambient sound level of 19 db at 40-db weighting and is virtually free from reflections. These results have been achieved with massive multilayer walls, floor, and ceiling which are covered as completely as possible with sound-absorbing material.

In order to approach anechoic (without echo) conditions, Fiberglas wedges with a sound absorption coefficient greater than 0.99 are used. A typical wall cross section consists of 12-inch reinforced concrete, 2-inch Fiberglas, 8-inch concrete block, 6-inch air space, and 28-inch Fiberglas wedge. The wedges may be seen in Fig. 1.

The anechoic property of the room is measured by comparing the curve of noise level versus distance from a point source with the inverse square law.[1,2] Deviation from the inverse square law is less than 1 db at distances as large as 16 feet in the frequency range 120 to 840 cycles per second.

The room is lined with 0.030-inch copper sheet attached to the concrete block wall. This provides r-f shielding so that measurements may be made of the radio and television interference caused by transformers.

The anechoic chamber, believed to be the largest in existence, provides a working space 58 feet long, 48 feet wide, by 43 feet high. It will accommodate transformers rated 500,000 kva or more which may weigh as much as 400 tons fully assembled.

A notable feature of the building is the main door, made up of two leaves, covering an opening 30 feet wide by 37 feet high. Each leaf of the door weighs about 30 tons and is supported by power-driven wheels operating on rails. The doors are sealed by a rubber gasket, which is inflated with compressed air and wedges itself between the door and the frame.

Operating personnel and small test equipment are supported on a trampoline-like floor consisting of stranded steel cables interwoven on 2-inch centers. The cables are held in tension by individual 450-pound springs. A plywood floor is sometimes installed on a separate rigid frame and simulates the condition of a transformer installed on a reflecting surface such as the ground.

Given a test chamber of adequate quality, the burden of minimizing sound level measurement error falls upon the measuring equipment. While errors up to ±2 db can be tolerated in many industrial applications, an over-all instrumentation accuracy of ±0.5 db is demanded here. The familiar single-crystal microphone has been superseded by two pairs of highly stable Western Electric *640AA* condenser microphones, working from opposite sides of the anechoic chamber. Weighting networks have been adjusted to within ±0.3 db of the American Standards Association design objective.[3] True rms indicating instruments have been provided with less than ±0.2 db variation from uniform response from 80 to over 4,000 cycles per second.

The reduction of reflections and instrument errors permits more accurate evaluation of transformer noise. These facilities will, therefore, contribute considerably to the research and development programs already in progress in the fields of metallurgy, vibration analysis, and transformer design.

Fig. 1. Interior of anechoic chamber

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Improving Field Analogues by Transformations

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A CONDUCTION analogue such as the electrolytic tank is a familiar device for the solution of problems involving electric, magnetic, thermal, and other fields. The accuracy of measurements made in this way is often limited by distortion of the field produced by the boundaries of the conducting medium and by practical limitations on the size of the model. In 1949 Boothroyd, Cherry, and Makar[1] described an ingenious circular double tank which was used for the study of impedance functions and which essentially eliminated the usual errors caused by the tank walls. Their technique is actually a special case of a general method based on conformal mapping.

In connection with conduction analogues it is useful to extend conformal mapping to electrostatic fields in dielectrics where the permittivity may vary with position (composite dielectrics) and to analogues of such fields. In doing so one has only to observe the requirement that the permittivity (or its analogue) remain invariant under the transformation. It is, therefore, possible to construct a model representing a conformal transformation of a field, even for nonuniform dielectrics, provided that the depth of electrolyte in the transformed model is the same at any point as it would be at the corresponding point of a model which represented the field directly.

Fields associated with figures of revolution can be regarded as a special case of translationally symmetric fields of varying permittivity and, hence, are also susceptible to a conformal transformation.

A type of conformal mapping which is very useful for conduction analogues is an inversion in a circle. Fig. 1 shows how such mapping transforms a field of infinite extent into a finite field which can easily be represented in an electrolytic tank without boundary errors.

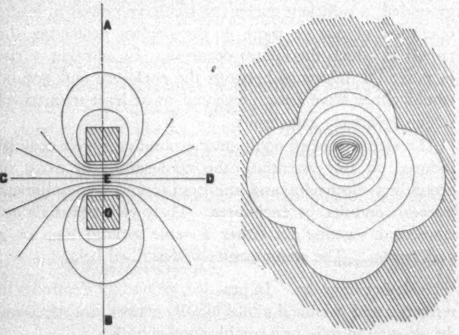

Fig. 1. Application of conformal mapping to the construction of a model for the electrostatic field between two conductors of square cross section. (Left) the original field spreads out to infinity in all directions; (right) inversion in a circle centered at 0 leads to field, where entire field is enclosed by the outer electrodes

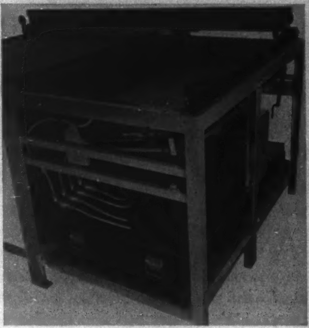

Fig. 2. Auxiliary (lower) tank connected to primary sloping tank

Even for fields of finite extent the proper transformation will lead to a model which represents the region of interest on a large scale and suppresses other regions.

In some problems it may be desirable to retain the region of interest in its original form. It is possible to do this and still realize the advantages of the conformal transformation by the use of a double-layer model. The method developed[1] is useful for problems of translational symmetry. Fig. 2 illustrates a double tank used for problems of rotational symmetry. The upper or "primary" tank is the ordinary tank with a flat sloping bottom used for the direct representation of fields having the symmetry of a figure of revolution. The entire region external to the primary tank (including points at infinite distance) is represented in the lower "auxiliary" tank by means of a suitable transformation.

Checks made using the auxiliary tank or a single tank with conformal models have given good agreement with theory on those configurations tested which were susceptible to calculation. The technique of conformal transformation of models for the electrolytic tank has made it possible to obtain good accuracy on configurations whose study would have been virtually impossible with conventional analogues.

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Digest of paper 55-105, "Improving Field Analogues Through Conformal Mapping," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 1, 1955. Scheduled for publication in AIEE *Communications and Electronics*, 1955.

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Grounding, Bonding, and Lightning Protection in Oil Refineries and Chemical Plants

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Discussions of grounding equipment, grounding for protection against lightning, static charges, and grounding systems and corrosion are presented, and various aspects of grounding practice in the oil industry are reviewed.

A RECENT SURVEY of engineers engaged in the petroleum and chemical industries indicated a wide variation in recommended grounding practices. To clarify the situation, a brief review of the various aspects of the problem as they occur in the industry is given. Thus, attention will be directed toward those situations most commonly encountered and to procedures designed for the protection of personnel, equipment, and plant.

EQUIPMENT GROUNDING

IN SPITE OF comprehensive provisions in the National Electrical Code (NEC) for equipment grounding, it is apparent that actual grounding installations are sometimes inadequate, or at best, haphazard. Records continue to report numerous accidents and an occasional death each year due to faulty equipment grounding. Most of these accidents could have been prevented by adequate grounding. This is certainly an important factor in providing safe working conditions for personnel. Inadequately grounded equipment in process units such as oil refineries and chemical plants may offer a very serious hazard due to the nature of the plant, equipment, and structures involved.

Large sums are spent each year in refineries and chemical plants to provide electric systems which will be safe to operate in the presence of flammable or explosive vapors and liquids. Equipment subject to arcing is either carefully enclosed in a flameproof and explosion-resistant housing, immersed under oil, placed in a pressurized switch room, or located entirely apart from the immediate area of potential hazard. There is no question of the wisdom of these extreme precautions in dealing with the potentials of explosion and fire with attendant personnel injuries, damage to property, and resulting loss of revenue. The fact must also be appreciated that inadequately grounded and ungrounded electric equipment may, under certain circumstances, create the very conditions which the design of the electric distribution system within the hazardous area attempted to avoid.

What is meant by equipment grounding? Article 250 of the NEC, in essence, requires that exposed conductive materials enclosing electric conductors and electric equipment or forming a part of such equipment shall be grounded for the purpose of preventing a difference of potential between the equipment and ground. Briefly then, an adequate method must be provided by means of which all noncurrent-carrying parts of the electric system may be maintained at the same potential. Also, that potential differences between various elements of the system and earth be eliminated or at least limited to safe values. A plant grounding system should do this.

The necessity of grounding electric equipment is readily apparent when the results of accidental contact between elements of the electric circuit and a metallic enclosure are considered. Upon such contact, the enclosure—be it motor frame, steel conduit, or controller housing—at once assumes the potential with respect to ground of that element of the electric circuit with which it has come in contact. If the enclosure has not been intentionally grounded, it may be considered to be connected to ground through a high resistance. This condition may result in a potential difference with respect to ground that will be dangerous to personnel. If there be a flow of current through a leakage path, there is also a potential danger of fire because of the heating of flammable material in the path. The mere presence of potential on the equipment may result in arcing which would constitute a serious hazard in plants handling flammable products.

On the other hand, had the enclosure been adequately grounded, a sufficient current would have flowed to insure operation of one or more of the devices protecting the circuit in which the failure occurred. In addition, a rise in potential difference between the enclosure and ground would either have been prevented or at least maintained within relatively safe limits.

The elements of an equipment grounding system may be reduced to two essentials, the connections to earth or grounding electrodes and the connections to equipment frames, conduits, or enclosures. These two essentials are connected together by either a cable ground loop or a grid system. The components are described below.

Grounding Electrodes. In practice, grounding electrodes in refineries and chemical plants usually consist of water lines, driven ground rods, or a combination of both.

A typical ground rod electrode installation is shown in Fig. 1. It should be noted that the construction is so designed that easy access is possible and that the conductor may be removed from the ground rod to facilitate testing. The NEC and the National Electrical Safety Code (NESC)

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permit values of resistance to ground of 25 ohms for this type of connection.

A typical grounding connection to water pipe which is a preferred type of ground is given in Fig. 2. Because of the low resistance to earth of such pipes no provisions are made for access and testing of the efficiency of the grounding. The NESC limits values of resistance to ground of this type of connection to 3 ohms.

Connections to Fixed Equipment. Connections between fixed equipment to be grounded and the grounding electrodes are usually made with stranded copper conductors. Sizes may vary as specified by the NEC, ranging from no. 8 to 3/0 American wire gauge depending upon the size of the service conductor. Exact grounding conductor size may also be determined by the maximum available fault current and the circuit protective device interrupting time.

The actual grounding connections between equipment and grounding electrode usually take the form of a loop to which the individual equipment may be joined by short cable connections. The loop is then connected at one or more points to grounding electrodes. This main grounding loop or bus which will serve motors driving process equipment, lighting panels, motor control, and other electric equipment should be buried at least 18 inches below finished grade. All below grade connections to the ground bus should be made by copper brazing, fusion welding, or equivalent process capable of sustaining reasonable temperature. Bolted connections should be avoided because of the danger of high-resistance joints due to corrosion.

Connections to individual pieces of electric equipment take a variety of forms. Grounding of motors is best accomplished by drilling and tapping the motor frame after which the grounding conductor, equipped with a copper terminal, may be bolted directly to the frame. Satisfactory protection from physical damage may be afforded the grounding conductor, if a suitably formed length of 1/2-inch conduit has been cast in the pump foundation block. Fig. 3 illustrates this clearly.

Similar grounding connections should be provided at lighting panels, motor starters, switchboard frames, switchgear ground busses, steel instrument control boards, and all other metallic enclosures and supports of electric apparatus. Some equipment is supplied with grounding lugs by the manufacturer, others must be tapped—as are the motors—to receive a grounding connection.

A point sometimes overlooked by the designer is the case of conduits terminating just above grade in motor control centers and cubicle-type switchgear. Since such conduits are not connected electrically to the equipment, they should be strapped to the enclosure or to the equipment ground bus if one has been provided. Grounding bushings are useful for this purpose.

Portable Electric Equipment and Welding Machines. It is usual practice in petroleum and chemical plant installations to include a system of convenience outlets providing local sources of power for portable equipment. The use of lower voltages for small hand tools and hand lamps definitely diminishes the danger to operating and maintenance personnel. It does not eliminate possible undesirable arcing in hazardous areas when equipment fails.

Portable equipment including welding machines should be grounded by means of a separate grounding wire in the connecting cable, of current-carrying capacity equal to that of the line conductors. The plug and receptacle should be equipped with special grounding contacts. In existing plants equipped with two wire receptacles, the third or grounding conductor in the connecting cable may be furnished with a spring clip which may be attached to grounded structural members or grounded steel conduit. The use of small lugs designed to be slipped beneath a screw head is undesirable since personnel habitually neglect to make this type of connection.

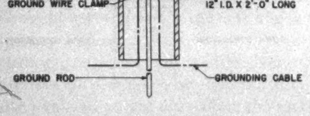
Substations. A satisfactory grounding system for substations may be achieved by installing a ground cable or ground bus underground, surrounding the substation area and connected at intervals to ground rods. A connection to metallic underground water piping is desirable. In larger substations, a grid may be formed by installing several underground cables across the substation area to connect opposite sides of the ground bus.

All electric equipment installed in the substation should be connected to the ground bus. Substation fences should be similarly connected to the bus at frequent intervals and structural steel substation structures should also be grounded in at least two locations.

The objective of substation grounding as described above is to insure that all parts of structures and equipment enclosures be at ground potential. In the event of a breakdown in insulation, flashover, or accidental contact with high voltage, the potential difference between the equipment and any point on the ground should not be great enough to constitute a hazard to personnel.

GROUNDING FOR PROTECTION AGAINST LIGHTNING

IN THE SIMPLEST TERMS, lightning may be defined as an electric discharge between earth and clouds. Obviously lightning, while an unwelcome visitor anywhere, could


REMOVABLE CAST CONCRETE COVER
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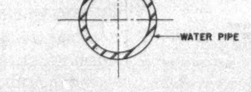


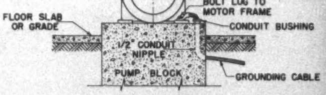


Fig. 1 (left). Ground rod electrode. **Fig. 2 (center).** Water pipe grounding connection. **Fig. 3 (right).** Motor grounding connection be calamitous in a plant handling explosive materials. Lightning can be responsible for damage of two types: one, the destruction resulting from a direct stroke, and the other, the impairment of equipment due to surges in the electric system, caused either by direct strokes to power lines at some distance from the plant, or by electrostatically induced voltages.

Complete positive protection from lightning hazards is not possible from a practical standpoint. The problem then lies in taking economical practical steps.

Pole Lines. Many plants are connected to overhead power lines operating either at utilization voltages or at higher potentials; such a distribution system invites lightning strikes. A high degree of protection for such lines can be achieved by the installation of lightning arresters on the line side of substations fed from overhead lines and at the terminus of an overhead line. Further protection for more extensive overhead systems may be obtained by the use of the overhead ground wire system. This method of shielding live conductors on pole lines has been very successfully employed through the years; its effectiveness, however, depends upon several factors. Ground resistance must be low. The installation must be so designed that the live conductors are not only widely spaced from the ground conductor but, for maximum protection, they must be within a shielded area below the ground wire. Experience and tests with lines indicate that the shielded area is that space included in an isosceles triangle having the grounded conductor as its apex and its base angles of approximately 60 degrees. As this angle decreases, the probability of flash to the conductor increases. Fig. 4 illustrates pole line shielding.

Under some conditions, it is desirable to provide individual motors, particularly those of larger size, with additional protection from lightning impulses. It is preferable to install the protective devices as near the machine to be protected as possible. This objective cannot be fully realized in hazardous areas since surge protective equipment is not readily available in explosion-proof construction. It is usually feasible to find some point either in or near the process area, however, where such protective equipment may be safely installed. With the increased use of pressurized switch rooms, the authors have found it possible to furnish a reasonable degree of protection by installing surge protective equipment on motor starter busses and, when required, directly on feeders to selected large motors.

Structures and Buildings. In general, it may be said that the fundamental theory of lightning protection for buildings is to provide means by which a discharge may enter or leave the earth without passing through a nonconducting part of the structure.

Since most of the structures in refinery and chemical plant units are of steel, a high degree of protection is possible by the simple expedient of grounding the steel framework in several places. It is probable that some of the higher steel structures, thus grounded, do receive occasional lightning strokes with no appreciable damage. They may be considered as self-protected against lightning strokes.

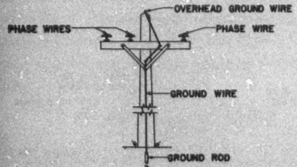
High structures such as those discussed above, create a zone of protection about their bases. The zone of protection is conventionally taken as the space enclosed by a cone, which has its apex at the highest point of the structures and a radius at the base taken as equal to the height of the structure in critical cases or up to twice the height in those of lesser importance. Fig. 5 illustrates a zone of protection. Consideration should also be given to the necessity for a lightning protection system for wooden and similar nonconducting structures.

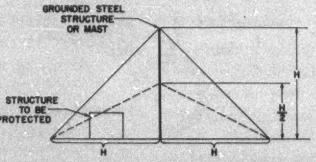
Vessels and Tanks. Properly grounded steel vessels and tanks are essentially self-protecting or may be considered protected if located in a zone of protection as defined above. Certain definite precautions should be observed, however, in the protection of the vessel and its contents. The following procedures are of value in this respect:

1. Flammable liquids and gases should be stored in all-metal structures, essentially gastight.
2. Vapor or gas openings to the atmosphere should be protected against the entrance of flame.
3. Positive metallic contact of piping to vessels to eliminate spark gaps at points where there may be an escape or an accumulation of flammable vapors must be assured.
4. In extreme cases, it may be necessary to establish zones of protection through the use of grounded masts and overhead grounded networks of wires or other similar provisions making up a protective cage.

In addition, it is recommended that all parts of steel tanks be in metallic contact as provided by riveted and caulked or welded construction and that all fixtures be in intimate electrical contact or bonded. It should be noted that steel tanks with wooden or other nonmetallic roofs have a relatively poor record of safety.

Chimneys and Flare Stacks. Metal chimneys and flare stacks need no protection against lightning other than that afforded by their construction, provided they are properly grounded. Metal flare stacks are usually remotely located from process areas and rarely fall within a zone of protection





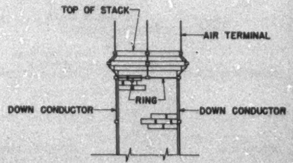


Fig. 4 (left). Pole line shielding. Fig 5 (center). Zones of protection. Fig. 6 (right). Arrangement of air terminals on stack

from other structures. In such stacks, it is also desirable that metal guy wires and cables be grounded at their lower ends. Guy wires attached to steel anchor rods set in the earth may be considered as sufficiently well grounded. Guy wires set in concrete or attached to buildings or nonconducting supports should be provided with additional grounding facilities. Vent stacks situated at the top of process structures can usually be considered as adequately grounded through the vessel or supporting structural steel.

Special precautions must be taken with chimneys and stacks of nonconducting materials such as brick, tile, concrete, or similar material liable to damage by lightning. It is customary practice to install air terminals (lightning rods) uniformly about the top rim of the stack at intervals not greater than 8 feet. The air terminals should be connected together by means of a metal ring or band forming a loop about 2 feet below the top of the chimney. The air terminals must then be connected to ground by at least two down conductors installed on opposite sides of the stack. Where stacks have a metal lining, the lining should be connected to the air terminals at its upper end and grounded at the bottom. Reinforced concrete stacks should be treated as above, but in addition, the reinforcing metal should be electrically connected together and bonded to the down conductors on the outside of the stack at the top and bottom of the concrete. A typical arrangement of air terminals on a stack is shown in Fig. 6.

STATIC CHARGES

INDUSTRIAL PLANTS such as refineries and chemical plants may have a potentially hazardous condition because of the accumulation of static charges due to a number of causes, among them, the movement of gases and liquids, the spraying of caustic solutions in tanks, acid bubbling, and even certain phases of the processes themselves. Liquids in a tank, if agitated, may accumulate static charges. It has been noted that liquids discharging from a pipe above the surface of the liquid in a storage tank will produce static charges in the liquid.

Fortunately, most of the problems presented can now be dealt with. Static caused by the flow of gases or liquids in piping systems is probably carried off harmlessly by the piping itself. This is particularly true in refinery work because of the continuous electric path provided by present-day pipe welding procedures. Potentials on piping may also be dissipated through pipe hangers and other supports electrically bonded to grounded structures. On occasion, however, it may be necessary to provide grounding for certain piping. This can usually be best determined after plant operation has begun.

Each time that an oil tank is filled, a degree of turbulence exists which probably results in the formation of static charges in the oil and on its surface. Since petroleum is a dielectric, it has the capacity for holding electric charges. Grounding of the shell of the tank and of the piping attached thereto, while important, is not the entire solution since the electric charges are not readily given up by the petroleum product involved. When the potential gradient becomes steep enough an arc over along the surface of the oil to the tank shell may occur. The oil industry has evolved at least two practical solutions to the problem. One lies in the reduction of turbulence and the other in the provision of steam smothering systems. As an added precaution, petroleum products should be introduced into storage tanks near the bottom and preferably discharged against the grounded shell where some portion of the static may pass from the fluid to ground.

GROUNDING SYSTEMS AND CORROSION

THE authors believe that one aspect of their present grounding methods deserves further consideration. Review these practices for a moment. Everyone is aware of the network of underground conduits and metallic piping which exists in most process areas. Current grounding practices usually call for the installation of bare stranded-copper conductors for direct earth burial and copper-clad ground rods.

Most soils contain a certain amount of moisture and salts, and are therefore fairly good electric conductors. The electrolytic nature of the soil gives rise to a bimetallic (galvanic) corrosion cell in which the buried steel pipe or conduit is the anode, while the bare copper cable or copper-clad ground rods act as the cathode. Since the ground rods and the buried piping are connected by the copper grounding cable, the circuit is completed and current flows through the soil from the steel to the copper. Wherever current leaves the steel, an electrochemical equivalent amount of metal is dissolved, and a corrosion pit results. Galvanic corrosion occurs only at the anode (bare or galvanized steel) and never at the cathode (copper). This preferential or sacrificial corrosion of the less noble metal is the fundamental principle of cathodic protection. In this case, however, the cathodic protection is definitely undesirable, since the expendable copper is afforded protection at the expense of the costly steel piping.

The corrosive action of such a galvanic cell may be reduced or retarded by either one of two relatively simple expedients. The first method consists of providing the grounding cables with an insulating jacket, generally of neoprene or other suitable plastic material. The high resistance of this insulation greatly reduces the flow of galvanic current. The alternate method of preventing corrosion of the pipe and conduits consists of substituting zinc rods or electrodes for the copper-clad steel rods. Since zinc is definitely anodic to steel, the polarity of the galvanic cell is reversed; that is, the sacrificial corrosion of the zinc ground rods (which can be periodically replaced) affords cathodic protection to the buried steel piping or structures. The latter procedure is meeting with favor among corrosion engineers.

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Magnetic-Amplifier Control of D-C Motors

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THIS digest presents the results of an analytical and experimental study of the steady-state operation of a d-c motor with armature power supplied through metallic rectifiers and controlled by saturable reactors or magnetic amplifiers.

The speed-torque characteristics of the d-c motor were determined as a function of control current for the various control methods. Also, the effectiveness of simple feedback connections and the use of external armature-circuit inductance was ascertained in improving the speed regulation.

Analysis shows that control of armature power by means of a saturable reactor produces a motor speed-torque characteristic of torque dependent only on the control current of the saturable reactor and independent of speed, that is, a constant-torque characteristic. Where armature power is supplied from rectifiers, the motor speed-torque characteristics are seen to depend on the continuity of the armature current, which is a function of the inductance-to-resistance ratio of the armature circuit. When this ratio is increased by adding an external inductor and continuity of the armature current is insured for magnetic-amplifier control, the magnetic amplifier appears to the armature as an energy source with fixed internal resistance and an internal voltage that is dependent only on the control current.

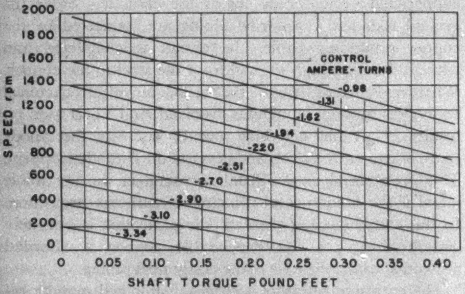

Fig. 1. Measured speed-torque characteristics of the d-c motor operating with magnetic-amplifier control

For this source the predicted speed-torque curves of the motor are straight lines. Also, the no-load speed depends only on the control current and the drop in speed from the no-load value for increasing torque depends on the circuit resistance.

The experimental work was carried out with a 1/8-hp d-c motor supplied from a metallic rectifier and controlled either by a saturable reactor or by a magnetic amplifier. The field current was held fixed. Only continuous conduction of the armature current was considered for magnetic-amplifier control.

The measured speed-torque characteristic curves of the motor are in accord with the predicted behavior. The family of curves for magnetic-amplifier control are shown in Fig. 1.

Two modes of feedback to a control winding on the magnetic amplifier were studied for improving the speed regulation of the motor. In the first method, an additional control signal proportional to armature current is applied to the magnetic amplifier. This compensation makes it possible to obtain zero speed regulation at the lowest speed of the family of speed-torque curves and correspondingly less correction for speed drop at the higher speeds in the range. In the second method, an additional signal proportional to the error between the armature voltage and a reference voltage is fed back to the magnetic amplifier in addition to the armature-current signal. The resulting curves are shown in Fig. 2.

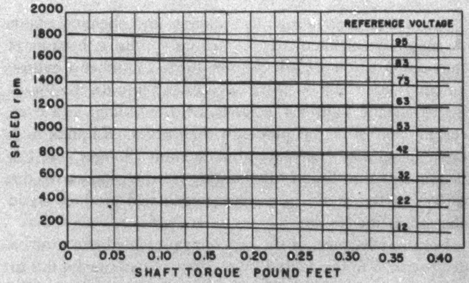

Fig. 2. Characteristics of the d-c motor operating with the magnetic-amplifier control, in which compensation is proportional to armature-current and armature-voltage feedback

Speed control of a d-c motor can be obtained by using a saturable magnetic device to control the power delivered by metallic rectifiers to the armature circuit. In addition, simple feedback circuits to the magnetic device can provide considerable flexibility in the speed-torque characteristics of the motor.

Digest of paper 55-60, "Magnetic-Amplifier Control of D-C Motors," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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Steam Turbine-Generator Operation and Maintenance

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THE Southern California Edison Company, with approximately 2,187 megawatts (mw) of effective operating capacity, 52 per cent of which is steam driven, is a participant in the 8,800-mw Pacific Southwest power area. In this operating area, the load changes on the systems and interchange of power across the interconnecting ties will on occasion impose rate-of-generation changes of 25 to 30 mw per minute, for periods of relatively short duration. The control of the tie line load and combined system frequency is maintained by automatic load- and frequency-control equipment, with one system regulating frequency, and the remaining systems controlling their ties with the regulating system.

The sequence of loading and unloading the steam generating plants conforms to rigid economy factors. Thus, the load increases are normally made at the plant which can make them at the lowest incremental cost rate, and the load reductions at the plant operating at the highest incremental cost rate. Wherever practical, block loading increments are assigned on the basis of operating the units at the wide-open valve positions. The application of this philosophy also is made at the full-load point of the generator, except where limited by boiler capacity.

The steam station generators are operated close to unity power factor, generally in the range of 0.98 to 0.99 lag, with no effort currently being made to operate in the under-excited region.

An analysis of basic design features of Edison steam turbine-generating plants constructed since 1945, indicates that the generators are 3,600 rpm, hydrogen cooled, and operate at 13.8 kv to 18 kv with ungrounded neutrals. With a few exceptions, field excitation is provided at 250 volts or 375 volts d-c by motor-generator sets, operating with rotating amplifier-type voltage regulators. Power for auxiliaries is supplied at 4,160 volts from auxiliary generators, located on the shafts of the main units, with reserve backup from the system through stepdown transformers. Relay protection for the main generators consists principally of overlapping generator differential and unit differential protection, with a few installations of negative sequence relays in process. Operation of the hydrogen cooling systems is based on maintaining acceptable cold gas temperatures, generally below 40 C.

In the event of loss-of-field of a main generator, most of the net load on the unit is removed as rapidly as possible, using the "fast" position of the load limit, followed by immediate opening of the circuit breakers connecting the unit to the system. It is generally considered preferable on the Edison system, that out-of-step generators be removed from the system as rapidly as practicable. Where single generators are out-of-step with other generators in the same plant, the unstable unit is immediately removed from the line and resynchronized as soon as possible. When multiple generators in the same plant are not obviously out-of-step with each other, but have rejected load and are apparently out-of-step with the system, usually they are kept on the line for at least 1 minute, unless there is some compelling reason to do otherwise.

The treatment of generator differential relay operation is qualified by available spinning reserve, and by known or suspected facts attending the relay operation.

In the start-up of steam turbine generators from a cold start, very little difference in procedure exists; the essential difference is in the point of application of field to the generator, this being related to the manufacturer's recommendations. In the 3,600-rpm units of one type, field is applied at 3,000 rpm. The practice of field preheating is not presently employed. In unloading the units, under normal conditions, load is removed at the rate of 1 mw per minute, without field. Only in an emergency is it permissible to increase the field current to shorten the deceleration period.

It is the objective of the maintenance program to confine equipment failures to determinable periods consistent with operating schedules, to the fullest extent possible. To realize this objective requires added emphasis on the preventive aspect of maintenance and the use of searching test procedures.

The periodic inspections and tests are divided into the two categories of routine outages and overhauls. Routine outages on main units are conducted at all plants on a maximum interval of 90 days. These outages are usually confined to an 8-hour period, intended to provide an opportunity to check all functional equipment intimately related to operation of the units, and is in effect a verification test of turbine-generator safety devices. Trip tests are performed on circuit breakers; governor operation is checked; brushes, slip rings, and commutators are closely inspected; insulators are washed or wiped; and safety devices are carefully tested.

Overhauls on main units are conducted on a basic 3-year interval. On alternate overhauls, the generator rotor is removed to permit more extensive inspection. Among the items investigated are the generator iron, windings, wedges, blocks, lashings, main bearings, seals, and the bearing oil system.

Digest of paper 55-119, "Steam Turbine-Generator Operating and Maintenance Methods of the Southern California Edison Company," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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This paper, written at the request of the Synchronous Machinery Subcommittee of the AIEE Rotating Machinery Committee, provides selected information related to the operation and maintenance of steam turbine-generators as practiced on the Southern California Edison Company system. The methods outlined are the result of years of progressive development, and necessarily reflect the predominant characteristics of the system which they serve.

Recommendations of IEC Technical Committee 24:

ELECTRIC AND MAGNETIC MAGNITUDES AND UNITS

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The recommendations made by Technical Committee 24 of the International Electrotechnical Commission are presented. Although they have not as yet become official decisions, it is probable that they will be approved by the national committees as each decision was supported by a large majority of the delegates to the committee meetings.

MEETINGS of Technical Committee (TC) 24 on Electric and Magnetic Magnitudes and Units (EMMU) were held at Philadelphia, Pa., on September 10 and 11, 1954, during the Golden Jubilee of the International Electrotechnical Commission (IEC). It should be understood that the recommendations made by this committee, and given in the following, have been referred to the national committees of the various countries for an official vote under the 6 months' rule. Thus they are not as yet official decisions. However, since each recommendation was approved by a large majority of the delegates present from the various countries, it seems reasonable to expect that they will be approved by the national committees.

It is hoped that the reader will bear in mind that each action in the following account is the best that can be agreed upon at present and should be considered as the most practical clarifying step that can be taken now. Further progress depends on: 1. a more nearly perfect understanding of the phenomenon involved, and 2. a better agreement on the meaning of the technical words or language used in the exchange of different viewpoints. Both of these will come with time. The recommendations are listed in the following.

SIGN OF REACTIVE POWER

IN 1935, the IEC adopted the convention that the reactive power flow to an inductive receiver be negative. In 1946, an AIEE committee undertook a survey of the prevailing practice in the United States. They found that it varied, but that most power companies assumed the sign of reactive power to an inductive receiver to be positive. In accordance with this, the AIEE changed the standard to accord with this practice. This was brought to the attention of the IEC at the Paris meeting in 1950 and it was suggested that other countries review their usage. Since then, many of the countries have found that they are also using the sign of reactive power to an inductive receiver as positive. It is hoped that the question will be clarified by the following resolution, which was adopted, and with which the latest American Standard is in accord. Resolved that:

1. Reactive power flow to an inductive receiver be positive.
2. Only one kind of reactive power be considered and defined. This means that no qualifying adjective should be used with the term "reactive power."
3. Reactive power be completely specified by stating its amount and direction of flow.

NAME FOR MKS OR GIORGI SYSTEM

IT was recommended that the system which uses the fundamental units meter, kilogram, and second (mks) be officially known in the IEC as the Giorgi system.

It was recognized that the system which uses the fundamental units meter, kilogram, second, and ampere is referred to by many as the mksa system. This term is similar to the term centimeter-gram-second (cgs) system.

ASSIGNMENT OF NAMES "MAGNETIC POLARIZATION," "INTRINSIC INDUCTION," AND "MAGNETIZATION"

THE magnetic induction B at a given point in a magnetic field is represented by a vector the magnitude of which is equal to the maximum limit of the time integral of the electromotive force generated in small plane-conducting loop brought in from a region of zero magnetic field divided by the area, as the area approaches zero in a macroscopic sense. The maximum limit occurs for a particular orientation of the loop at the given point. The direction of the vector is normal to this loop.[1]

The magnetic field strength H at a given point is represented by the current per turn multiplied by the number of turns in a small elongated uniformly wound solenoid divided by its length when the solenoid is centered at the given point and is oriented and adjusted so as to counterbalance magnetic effects at that point.[2]

In vacuum the ratio $B/H = \mu_0$ is called the permeability of free space. In any other medium the ratio $B/H = \mu$ is called the permeability of the medium.

It was recommended that in a medium other than vacuum the term $B-\mu_0H$ be called "magnetic polarization"

Full text of paper 55-49, "Recommendations of IEC Technical Committee No. 24 on Electric and Magnetic Magnitudes and Units," recommended by the AIEE Basic Sciences Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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or "intrinsic induction," and that $(B/\mu_0)-H$ be called "magnetization." These terms are used by many authors and a name is needed for them. There was considerable discussion as to which of these two terms should be given preference in the recommendations. The views of the national committees will be obtained on this. Note: In the United States the symbol μ_v is used instead of μ_0.

NAME FOR UNIT OF MAGNETIC INDUCTION IN GIORGI SYSTEM

It was recommended that the name "tesla" be given to the unit of magnetic induction (the weber per square meter) in the Giorgi system.

Similarly, in the centimeter-gram-second electromagnetic (cgsm) system, there is the gauss, the unit of magnetic induction, which is equal to the maxwell per square centimeter.

RATIONALIZATION OF THE ELECTROMAGNETIC FIELD EQUATIONS

At the IEC 1950 Paris meeting TC 24 recommended that the mks system be used in the rationalized form. At that time, questions were raised as to whether rationalization by change of units or quantities was meant. Since then much discussion has been devoted to the subject. The following was recommended at the 1954 meeting:

"The rationalization of the equations of the Electromagnetic Field recommended by the IEC is characterized by the following principal equations whose form remains the same whether the symbols are regarded as the representing physical quantities coming into play or are regarded as representing their numerical values.

$$\oint H ds = \Sigma I$$
$$\phi = \int\int B dA$$
$$B = \mu H$$

$$\int\int D dA = Q$$
$$\psi = \int\int D dA$$
$$D = \epsilon E$$

"These equations apply to isotropic media. The total current (ΣI) includes in the general case the displacement current.

"The permeability of free space μ_0 has the numerical value $4\pi \times 10^{-7}$, where the unit is the henry per meter. The permittivity of free space ϵ_0 has the value of $(1/c^2\mu_0)$ or approximately the numerical value 8.85×10^{-12}, where the unit is the farad per meter.

"Table of Reference for the Quantities in the Above Equations

Name	Symbol	Unit of the Giorgi System	IEC Classification Number
Element of Length	ds	Meter	05-35-050
Electric Charge	Q	Coulomb	05-15-010
Electric Field Strength	E	Volt per meter	05-15-045
Permittivity	ϵ	Farad per meter	05-15-120
Electric Displacement Density	D	Coulomb per sq meter	05-15-130
Displacement Flux	ψ	Coulomb	05-15-135
Electric Current	I	Ampere	05-20-040
Magnetic Field Strength	H	Ampere-turn per meter	05-25-022
Magnetic Induction	B	Weber per sq meter	05-25-030
Magnetic Flux	ϕ	Weber	05-25-035
Permeability	μ	Henry per meter	05-25-045 "

RELATION OF AMPERE-TURN PER METER TO OERSTED

It was found that in the usage of various writers the relation between the ampere-turn per meter and the oersted was apparently not always the same. To secure uniformity, the following resolution was adopted:

"A current of 10 amperes in a wire of one centimeter length of arc, of a circle of one-centimeter radius, contributes at the center of the circle a magnetic field strength of one oersted.

"A uniform elongated solenoid having one turn per meter axial length in which there is a current of one ampere produces at the center of the solenoid a magnetic field strength of one ampere-turn per meter.

"The contribution to the magnetic field strength in the first case is equal to $1{,}000/4\pi$ times the magnetic field strength in the second case."

Here the first paragraph of the resolution uses the arrangement by which the abampere was defined by means of the oersted in the British Association Reports on Electrical Standards.[3] The second paragraph uses the arrangement by which the ampere-turn per meter is defined in the IEC vocabulary.[2] The third paragraph gives the relation between the two magnetic field strengths.

It will be noted that actual numerical examples are used in the resolution. This was done to avoid the use of symbols, since these are also used in different senses by different authors. It is hoped that the resolution will produce uniformity in the relation between the ampere-turn per meter and the oersted as used in future.

REVISION OF DEFINITIONS IN SECOND EDITION OF INTERNATIONAL ELECTROTECHNICAL VOCABULARY WITHIN SCOPE OF TC 24

Because of certain points which were discussed in the previous resolutions in connection with definitions prepared by TC 1, TC 24 agreed that it should consider carefully the definitions which were closely allied with its activities. Some definitions to which attention had already been called were those of reactive power, complex power, permeability, and permittivity.

COMPARISON OF SYSTEMS WITH THREE AND FOUR DIMENSIONS

At the 1950 Paris meeting the IEC adopted the ampere as the fourth preferred fundamental unit in the Giorgi system. The International Union of Pure and Applied Physics (IUPAP) adopted the ampere as the fourth fundamental unit in the Giorgi system in 1951.

Thus the mksa system is based on four fundamental units (meter, kilogram, second, and ampere). The two cgs systems (electrostatic and electromagnetic) are based on three fundamental units (centimeter, gram, and second). In the cgs electromagnetic system, the permeability of free space is assumed to have no dimensions and its numerical value is considered equal to 1. In the cgs electrostatic system, the permittivity of free space is assumed to have no dimensions and its numerical value is taken to be equal to 1. It was agreed that the relations among these three systems, each of which is based on a different assumption, should be studied and clarified. A memorandum by Dr. H. Konig and Dr. U. Stille has been prepared on this subject and will be circulated to the national committees for study.

PREPARATION OF DOCUMENT CONTAINING ALL DECISIONS OF TC 24 SINCE FOUNDING OF IEC

It was agreed that such a document should be prepared by the secretariat so that all the decisions of TC 24 from its beginning to date would be readily available.

It was pointed out that reference to other sources will probably be necessary later,[4–6] and that as a first step collecting the IEC decisions was desirable. The work on electric and magnetic magnitudes and units is carried on in this country by the American Standards Association Committee C61.

REFERENCES

1. British Association Reports on Electrical Standards. Cambridge University Press, Cambridge, England, 1913. See p. 520 for a similar way of defining magnetic induction.

2. International Electrotechnical Vocabulary. International Electrotechnical Commission, Geneva, Switzerland, 1954, IEC classification no. 05-25-022.

3. See reference 1, p. 102.

4. See reference 1.

5. Reports on Symbols, Units and Nomenclature of the International Union of Pure and Applied Physics. Physical Society, London, England.

6. Systems of Electric and Magnetic Units. *Bulletin No. 93*, National Research Council, National Academy of Sciences, Washington, D. C., 1933.

Ignitron Multiple-Unit Cars for the New Haven Railroad

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ASSOCIATE MEMBER AIEE

V. F. DOWDEN
ASSOCIATE MEMBER AIEE

The first quantity application of ignitron rectifiers on multiple-unit cars is described. The use of the rectifier system has many advantages as it combines the desirable characteristics of high-voltage a-c transmission with straight d-c traction motors and control equipment.

On APRIL 1, 1954, a 10-car train was placed in commuter service on the electrified lines of the New York, New Haven, and Hartford Railroad, the first of 100 new multiple-unit cars. Modern in every respect, the outstanding feature is the use of ignitron rectifiers to convert alternating current collected from the trolley to direct current for operation of d-c traction motors. This is the first application in the world of this type of equipment in quantity. Its use follows naturally from the excellent results obtained with ignitron-rectifier-type motive power on a trial multiple-unit car in service on the Pennsylvania Railroad since 1949, followed by two locomotives (nominally rated 6,000 hp each and operating at 8,400 hp each) which have been in operation on the same railroad since early 1952.

SERVICE OPERATIONS

The NEW CARS, built by the Pullman-Standard Car Manufacturing Company, weigh 78 tons without load and seat 120 passengers. Air conditioning and automatic heat control are incorporated to assure passenger comfort in every season. In contrast to existing motor cars, which employ hand acceleration and operate with trailers, the new cars are all equipped with four 100-hp motors and accelerate automatically at a fixed rate of 1.0 mile per hour per second, based on an average load of 60 passengers. All motor-car operation involves a minimum of terminal switching, assures uniform acceleration rates, and provides the greatest protection of equipment and schedules in case of a power failure of one car in a train. The equipment is capable of operating in either local commuter service or in express service.

During the first 6 months, the rectifier cars have operated a total of approximately 1,000,000 car miles. Counting days out of service for repairs and inspection, the availability factor has been 95 per cent. At present 50 trains are operated with the new cars on weekdays, 43 on Saturdays. On Sundays, 33 trains are operated with the new cars and, in addition, trains are at times operated from New Haven to New York on relief schedules. Two cars are

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Full text of paper 55-202A, "Ignitron Multiple-Unit Cars for the New Haven Railroad," recommended by the AIEE Land Transportation Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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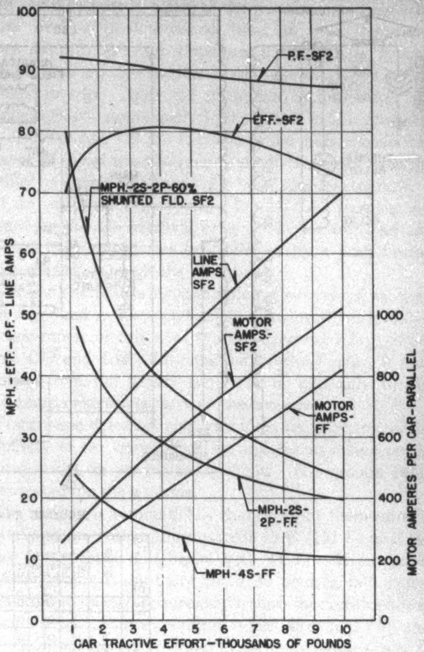
Fig. 1 (right). Performance of typical 6-car train for transmission system and generator drops:

Four WL.653-B ignitrons with four type-1451-A motors; 36-inch wheels, 122/23 gear ratio; Main line impedance = 0.705 + j1.69; Internal general voltage = 11,750; Average car heater + auxiliary motor load out of rectifier = 50 amperes d-c; One can a-c filter; Distortion factors based on laboratory tests



assigned to trains operated on the New Canaan branch and and operate about 288 miles per day.

Seven of the new cars are combination cars, each having a capacity of 92 passengers and 10,000 pounds of baggage. Four of the cars are fitted for and used in club-car service. One of these cars is equipped with a small buffet.

PERFORMANCE

The performance of a typical 6-car train operating from the 11,000-volt a-c trolley is presented in Fig 1. The performance from the 650-volt d-c third rail is shown in Fig. 2.

CONTROL SYSTEM

A schematic diagram of the main circuit is given in Fig. 3. It can be seen that the major portion of the main and auxiliary circuits are the same whether the car is operating in the a-c or the d-c zone. Only the power supply differs. In the d-c zone the changeover switch connects the traction motor circuits and the d-c auxiliary circuits between the third-rail shoes and ground. In the a-c zone the changeover switch connects these same traction-motor and auxiliary circuits between the ignitron tube cathodes and the transformer mid-point through the main d-c reactor.

On the first notch of the master controller, all motors and accelerating resistance are connected in series with the first step of field shunting to provide smooth starting. In both the a-c and d-c zones, resistor acceleration with a bridging transition is used with two steps of field shunting in the parallel combination for high-speed running. The acceleration is automatic at a fixed current rate under the control of the limit relay.

RECTIFIER D-C SUPPLY

The d-c power in the a-c zone is supplied from a 25-cycle single-phase full-wave rectifier. See Fig. 3. The anode balance coils assure equal load division to the two rectifier tubes connected in parallel. The d-c chokes are used to limit the a-c component of the rectified direct current to values which the motors will commutate satisfactorily. The air-brake compressor motor and car heaters do not require a d-c choke to operate from the rectified direct current, and therefore are connected from the cathode to the transformer mid-point.

TRACTION MOTORS

The traction motors are self-ventilated with single reduction gearing and flexible couplings. They are 325-volt d-c series-wound commutating-pole motors, and insulated for operation two in series on a maximum of 750

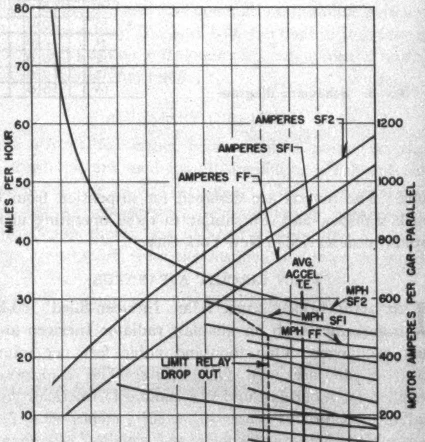
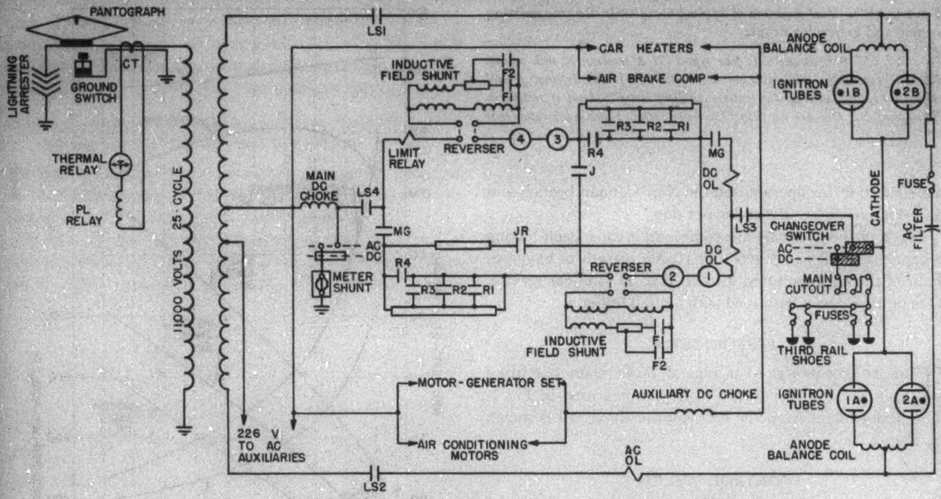


Fig. 2. Notching curve, third-rail zone 650 volts d-c:

Four type-1451-A traction motors, 36-inch wheels; 122/23 gear ratio


PANTOGRAPH
LIGHTNING ARRESTER
GROUND SWITCH
CT
THERMAL RELAY
PL RELAY
11000 VOLTS 25 CYCLE
LS1
LS2
CAR HEATERS
AIR BRAKE COMP
INDUCTIVE FIELD SHUNT
F2
F1
LIMIT RELAY
REVERSER
4
3
R3
R2
R1
R4
J
MG
DC OL
MAIN DC CHOKE
LS4
LS3
JR
AC
DC
METER SHUNT
REVERSER
2
1
INDUCTIVE FIELD SHUNT
MOTOR-GENERATOR SET
AIR CONDITIONING MOTORS
AUXILIARY DC CHOKE
226 V TO AC AUXILIARIES
AC OL
ANODE BALANCE COIL
IGNITRON TUBES
1B
2B
1A
2A
CATHODE
FUSE
AC FILTER
CHANGEOVER SWITCH
MAIN CUTOUT
FUSES
THIRD RAIL SHOES

SEQUENCE CHART DC

CONT'R	STEP	LS 1	LS 2	LS 3	LS 4	JR	J	MG	R 1	R 2	R 3	R 4	F 1	F 2
OFF														
1	1			O	O	O							O	
2	2			O	O	O								
	3			O	O	O			O					
	4			O	O	O			O	O				
	5			O	O	O			O	O	O			
	6			O	O	O			O	O	O	O		
	7			O	O		O							
3	TRAN			O	O		O	O						
	8			O	O			O						
	9			O	O			O	O					
	10			O	O			O	O	O				
	11			O	O			O	O	O	O			
	12			O	O			O	O	O	O	O		
	13			O	O			O	O	O	O	O	O	
	14			O	O			O				O		O

SEQUENCE CHART AC

CONT'R	STEP	LS 1	LS 2	LS 3	LS 4	JR	J	MG	R 1	R 2	R 3	R 4	F 1	F 2
OFF		O	O											
	1	O	O	O	O	O							O	
2	2	O	O	O	O	O								
	3	O	O	O	O	O			O					
	4	O	O	O	O	O			O	O				
	5	O	O	O	O	O			O	O	O			
	6	O	O	O	O	O			O	O	O	O		
	7	O	O	O	O		O							
3	TRAN	O	O	O	O		O	O						
	8	O	O	O	O			O						
	9	O	O	O	O			O	O					
	10	O	O	O	O			O	O	O				
	11	O	O	O	O			O	O	O	O			
	12	O	O	O	O			O	O	O	O	O		
	13	O	O	O	O			O	O	O	O	O	O	
		O	O	O	O			O				O		O

Fig. 3. Schematic diagram

volts. The motors are designed for suspension from the truck transom, and are similar to those operating in the rapid transit service in New York City.

MAIN CIRCUIT APPARATUS

THE MAIN TRANSFORMER is an Inerteen-filled 380-kva transformer with an air-blast radiator Inerteen-to-air heat exchanger. One thousand cubic feet per minute (cfm) of air are used for cooling. The transformer, designed for mounting under a standard American Association of Railroads center sill, is $52^{3}/_{4}$ inches wide, $29^{1}/_{4}$ inches high, $94^{3}/_{8}$ inches long, and weighs 7,840 pounds. The primary winding is 11,000 volts, 25 cycles. The secondary voltage from the mid-point to either end is 780 volts with one tap at 226 volts from the transformer secondary mid-point for a-c auxiliary circuits.

The a-c filter consists of two capacitors and resistors across the entire transformer secondary to suppress the induced currents in telephone lines adjacent to the electrified lines in the a-c zone of operation.

The four *WL-653B* ignitron-rectifier tubes are attached to a frame insulated and shock mounted from the main box construction. See Fig. 4. Insulation to ground is provided by using 13 feet of rubber hose connected to the inlet and discharge headers of the tubes for the closed-circuit cooling system. The water temperature is regulated by a temperature-sensing device and a 3-way valve to maintain the water temperature between 42 and 45 C by passing water through the radiator for cooling or by-passing the radiator to retain heat in the water. Water heaters are turned on automatically whenever the water temperature is below 25 C (77 F). The water system is protected from freezing by antifreeze. The radiator for the cooling system is located in the air intake to the blower. The air temperature is raised approximately 5 C and then utilized for cooling the main transformer and main d-c choke. There are two

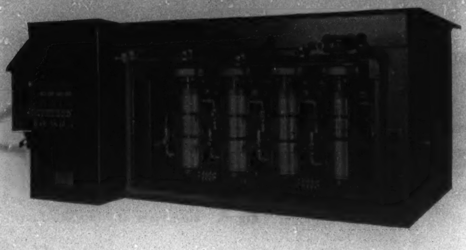


Fig. 4. Ignitron equipment box, rectifier tube compartment

excitation circuits of the nonlinear reactor type located at one end of the rectifier cubicle for excitation of the rectifier tubes. Misfire lights, one for each tube, have been provided to enable maintenance personnel to check the rectifier operation. The rectifier cubicle has been constructed in the form of a letter *T*. It is 29 inches high, 65 inches long, and 49 inches at its widest part. Three felt-sealed lift-off covers are provided for access to maintain the apparatus. The rectifier cubicle, located under the car, weighs about 1,880 pounds.

The major portion of the control apparatus is located in the main and auxiliary control box. The box contains the electro-pneumatic switches which serve as the a-c and d-c line switches, field shunting switches, the switches which short-circuit accelerating resistance steps, and those that set up the series and parallel motor combinations. Also placed in the box are the reverser, a-c/d-c changeover switch, operating and protective relays, auxiliary circuit breakers, electromagnetic contactors for car heaters, indicating lights, and a-c and d-c watt-hour meters. Fig. 5 shows the relative location of some of the apparatus in the main and auxiliary control box. The reverser and a-c/d-c changeover switch have handles extending through the bottom of the box so that they may be operated by hand if required.

The equipment boxes of previous multiple-unit cars operating on 650-volt third-rail systems have been mounted on insulators. The ignitron assembly, the main and auxiliary control box, and the regulator and control box for these new cars are bolted directly to the under frame of the cars without the use of insulators, to comply with Interstate Commerce Commission *EX Parte 179*. The additional insulation required in order to use a grounded-box structure is provided inside the boxes. Having these box structures grounded provides an added degree of safety for the personnel servicing the cars. Screens protect personnel from the ungrounded parts of the accelerating resistors, field shunts, auxiliary reactor, and a-c filter resistors. Fig. 6 shows a side view of the completed car. Figs. 7 and 8 show views of the car interior and operating position respectively.

PROTECTIVE APPARATUS

THE MAIN TRANSFORMER is protected from primary overloads by the pantograph-lowering (pl) relay. If the primary current exceeds 460 amperes, it is tripped magnetically, or if current in excess of the transformer rating continues over a predetermined time, it trips thermally. When the pl relay trips, it operates the pneumatic ground switch which grounds the line causing the substation circuit breaker to trip. After the substation breaker trips, the pantograph is automatically lowered and locked down on the defective car. If the Inerteen of the main transformer exceeds 85 C, the traction motors are disconnected from the rectifier by opening *LS3* and *LS4;* this lights an indicator.

If an arc back occurs, the *LS1* and *LS2* switches are opened by the a-c overload relay. The a-c overload can be reset from the master controller or by a push button which extends through the box cover.

The d-c overload is a combination of two relays, an overload relay and a line switch relay. An overload in either traction-motor circuit trips the d-c overload relay, which opens *LS3* and *LS4.* Like the a-c overload relay, it may be reset from the master controller or manually by the push button extending through the box cover.

The ground detector relay trips if a ground occurs on the secondary of the transformer, or any circuit connected to it, and turns on an indicating light. The ground relay operates only in the a-c zone.

The rectifier is automatically shut down by thermostats if the tube jacket temperature exceeds 55 C (131 F) or if the water temperature falls below 5 C (41 F). If the water pressure, which is normally about 30 pounds, falls below 15 pounds an under-pressure switch shuts the rectifier down. Whenever any of these conditions are corrected, *LS1* and *LS2* are closed and the rectifier again supplies d-c power to the car.

A "power-on" relay is used to open the *LS3* and *LS4* switches of the main-motor circuits whenever there is a loss of d-c power due to third-rail gaps or bouncing pantograph. When *LS3* and *LS4* open, all main-motor switches open. On reclosing *LS3* and *LS4*, the control starts from the switching position and notches up automatically under the control of the limit relay.

AUXILIARY CIRCUITS

D-C MOTORS fed either from rectified power or the third rail are used for all auxiliaries which are required in both the a-c and d-c zones. The motor-generator (m-g) set, air compressor, air-conditioning compressor, and condenser motors are 650-volt d-c motors. The car heaters are supplied from the rectified power or the third rail.

The transformer and reactor blower and the trans-

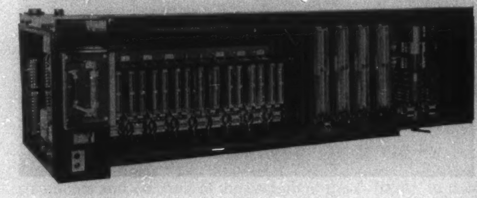


Fig. 5. Main and auxiliary control box, front view

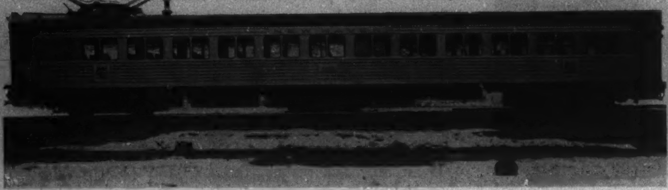


Fig. 6. Side view of completed car

former Inerteen pump are required only for a-c operation. The motors are capacitor-start capacitor-run induction motors which are fed from a 226-volt tap on the transformer secondary. The ignitron water heaters and anode heaters are fed from the third rail in the d-c zone and from the 226-volt tap through a 226- to 650-volt transformer in the a-c zone.

Sixty-four volts direct current for control, low-voltage auxiliaries, and battery charging is supplied from the generator of the m-g set. The motor of the m-g set is a 650-volt d-c compound motor which operates from either rectified or third-rail direct current. The control for the m-g set is located in the regulator and control box.

The 64-volt control battery is made up of 32 lead-acid cells with a rating of 144 ampere-hours at the 2-hour rate. The entire battery is housed in a single box having metal grating at the bottom and rear for drainage and ventilation. The battery floats on the generator with a charging voltage of 73 volts. No flushing has been necessary between inspection periods. The battery provides a 1-hour emergency stand-by supply in case of power failure.

The car body and saloon are illuminated by fluorescent lamps operated from a 2.0-kw safety-type motor-alternator. The lighting provides approximately 20 foot-candles at reading level. Twelve 60-volt 15-watt emergency lights are provided and are automatically controlled. Two 25-watt 60-volt incandescent flood lamps are provided in each vestibule. The marker lights are built in with 30-volt 30-watt lamps with series resistors. The headlight at each end is the conventional 60-volt 250-watt prefocused type with dimmer circuit.

Fig. 7. Interior view of car

The air-conditioning apparatus is rated at 8 tons dry. It is operated by a 2-speed motor direct connected to the compressor. The evaporator is blown by a 60-volt 2.0-hp blower which distributes either heated or cooled air at a normal rate of 2,400 cfm. When power fails, the blower is automatically speeded up to deliver approximately 3,000 cfm. This feature is necessary to provide increased ventilation, since during power failure the air conditioning cannot operate. The 650-volt d-c air-conditioning compressor and condenser motors operate in parallel on a single set of controls. The compressor motor is rated 11.5 hp and the condenser fan motor at 2.0 hp.

A total of 38.88 kw is provided for car body heating. There are two vestibule blower heaters each rated 1.5 kw and one overhead heater unit rated at 21 kw arranged for three steps of control: 7, 14, and 21 kw. In addition two circuits of wall heat, each 7.44 kw, and four body end blower heaters, each rated 750 watts, are provided. All heaters are thermostatically controlled except the two vestibule blower heaters which are manually controlled by the engineman. The wall heaters provide 60 F layover heat under the control of a separate thermostat.

CARBON BRUSH LIFE

ONE OF THE MAJOR LIMITATIONS on the older classes of multiple-unit cars has always been the short life of carbon brushes, particularly those used in the traction motors. Experience to date indicates that brush life on the new cars may be anticipated as follows:

Traction motors	85,000 to 90,000 miles
Ignitron pump motor	3 years
M-g set motor	9 months
M-g set generator	4$^{1}/_{2}$ months
Motor-alternator motor	12 months
Motor-alternator generator	3 years
Air-conditioning compressor motor	2 years
Air-conditioning condenser motor	3 years
Air-brake compressor motor	2 years

This anticipated brush life is based upon observations of performance during the first 6 months of operation. It is the authors' opinion that the brush life can be extended in some cases either by change of brush grade or by adjustment of pressure.

INSPECTION PERIODS

THE FIRST INSPECTION PERIOD on these cars was made after 4,000 miles of operation. Experience gained

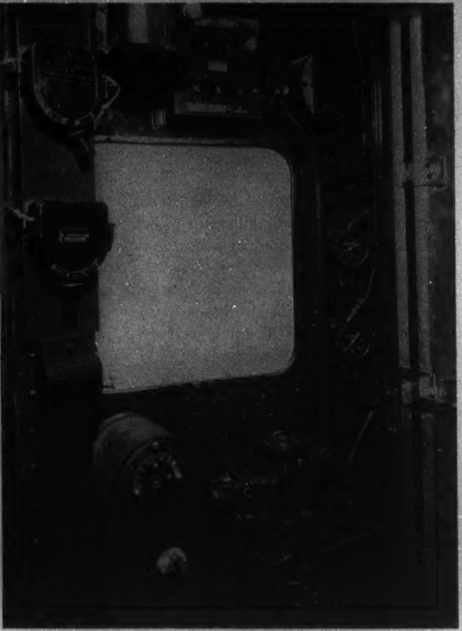


Fig. 8. Car operating position

from this inspection led to making the second inspection after an additional 16,000 miles of operation. Certain other inspection restrictions may be imposed; however, experience so far indicates that the new equipment should require minimal maintenance.

POWER CONSUMPTION

Preliminary tests on power consumption in local service show approximately 6.0 kwhr per car mile, in express service approximately 3.4 kwhr per car mile. These figures include heating or air conditioning and auxiliaries, but do not include stand-by losses. A-c stand-by losses are estimated at about 19 kwhr per car per hour, but operating conditions and practices have kept these losses to a minimum.

CONCLUSION

The use of the rectifier system is advantageous in that it combines the desirable characteristics of high-voltage a-c transmission with straight d-c traction motors and control equipment. Furthermore, auxiliary motors, such as the air compressor, the air-conditioning compressor, and condenser motors, are 650-volt d-c motors. The selection of 650-volt d-c motors for these auxiliaries made it possible to reduce the size of the control battery and the m-g set. It is estimated that the weight of the car would have been increased approximately 3,000 pounds if 64-volt air-conditioning motors and a larger battery had been used.

The rectifier-type motive power with its high power factor and efficiency, with the use of standard 650-volt d-c motors, is well suited to a-c electrification. The New Haven Railroad has an additional advantage by the use of rectifier motive power since the cars are required to operate over 11 miles of the New York Central Railroad's 650-volt d-c third-rail system into Grand Central terminal.

U. S. Air Force Demonstrates First Supersonic Flight Simulator

The U. S. Air Force recently demonstrated the first *F-100A* flight simulator to industrial representatives of the National Security Industrial Association, at Nellis Air Force Base, Las Vegas, N. Mex. This first supersonic flight simulator was made by Westinghouse Air Brake Company at Melpar, Inc., Falls Church, Va., a wholly owned subsidiary, while the production models of the *F-100A* simulator are being manufactured at Westinghouse Air Brake's Union Switch and Signal Division, Swissvale, Pa. It affords realistic classroom training, practice in emergency procedures too dangerous to perform in the air—such as a flame-out or landing-gear failure—and facilitates pilot performance evaluation prior to actual flight.

The Air Force has used flight simulators as a training aid since 1946, but the *F-100A* is the first to simulate a supersonic aircraft. A false move at supersonic speeds could mean pilot or plane loss. While the simulator only supplements actual flight training, it permits repeated schooling in procedures and techniques that ultimately enable the pilot to react instinctively during an actual emergency.

The *F-100A* flight simulator occupies an area 47 by 18 feet and consists of seven major assemblies and five electronic computer racks. Major assemblies include a cockpit in which are duplicated controls and instruments found in the actual *F-100A* aircraft, flash tubes simulate the effect of lightning, and twin speakers reproduce flight and engine noises for the pilot trainee. A flight instructor's console contains a duplicate of the simulator cockpit instruments and two control panels. Using the control panel switches, the instructor can set up various problems and observe the pilot's reaction to them. Various situations encountered in communication, navigation, cross-country, and approach procedures can be simulated. This simulator is designated as type *MB-3*. A 3-ton air conditioner supplies the instructor's room, while the pilot's cockpit is served by a $1^1/_2$-ton unit. The performance of the *F-100A* fighter can be conveniently expressed by mathematical functions and, therefore, is readily handled by an analogue computer. The *MB-3* simulator computing system duplicates the performance of the *F-100A* aircraft, and is connected to the instruments and controls of the cockpit of the *F-100A;* in this manner, the flight characteristics of the fighter are simulated.

The New Look in Lamp Bases

J. O. GEISSBUHLER

ALUMINUM is used presently in the lamp industry in many places. For example, it is the reflecting coating on all sealed-beam-type lamps. It is used also as a powder, where it has a beneficial effect on lamp performance, or in the manufacture of a heat reflecting disk to reduce the base temperature. But, by far, the largest amount of material and the newest use is for bases.

Bases provide the mechanical and electric connection for lamps, and consist usually of a shell and one or more center contacts insulated from each other and the shell by a glass or a plastic material. In the fluorescent lamp, however, the aluminum shell is not used to complete the electric circuit, nor does it contact a metal socket.

Traditionally brass had been the material for use in base manufacture. During World War II, a serious shortage of brass developed, necessitating a substitution. It became apparent very quickly that aluminum answered some of the primary requirements; it had good electrical conductivity, and good mechanical strength and stability. Cost analysis indicated that it would lower base costs and be in freer supply, compared to brass. But could it be adapted to manufacturing methods, and would it perform satisfactorily? These were the two primary questions.

Over the years, the engineers had worked very closely with the manufacturers of brass to develop high-speed manufacturing techniques. With the change of material, problems that had been solved in brass were retackled. In lamp-base manufacturing, the glass insulation is pressed into the shell at the melting temperature of the glass. Early aluminum alloys annealed at this temperature and were very soft. This problem was solved by reducing the glassing-in temperature of the glass, by changing to a higher-temperature aluminum alloy, and, in the glassing-in operation, by keeping the aluminum metal cool.

Lead-tin solders were not suitable for use on aluminum, as corrosion developed very quickly between the solder and the base material. Recently developed welders now weld the side wire to the base.

Does the new material perform well in the field? On standard-voltage lamps in a normal atmosphere there is no adverse effect of the oxide film on the electric connection, probably because the voltage is high enough to break down the thin oxide film and the current required is very low compared to the area of contact. On low-voltage lamps, the current density is relatively high, and a resistance can develop. Many tests were run; after the previously designed lamp was exposed to adverse weather conditions for a long period of time, a voltage drop (less than 0.2 volt) developed. This could be serious in automotive service, but a redesign has practically eliminated this resistance.

Aluminum is considered to have a high coefficient of friction, primarily because the thin oxide film formed on the surface of the metal can be broken so easily. Thus it was necessary to look for a lubricant which would alleviate this condition. Commercial consideration demands that this material must be odorless, colorless, and a hard wax. It had to be inexpensive, and the method of application such that it would not swallow the cost advantage that aluminum provided. The material that best met these specifications was a hydrogenated whale oil.

Another basic problem of aluminum is shown by a galvanic series for some common metals and alloys:

CORRODED END (+)
Magnesium and Alloys

Zinc
Aluminum
Cadmium

Duralumin

Steel, Iron
Cast Iron
Stainless (active)

Soft solders
Lead, Tin

Nickel, Inconel (active)

Copper
Brasses, Bronzes
Monel
Cupro-nickels

Nickel, Inconel (passive)

Stainless (passive)

Silver
Gold
Platinum
PROTECTED END (−)

Metals that are grouped close together have little galvanic action, and the galvanic action increases as the two metals in question are separated in this series. Aluminum stands quite high in the galvanic series compared to brass. Most of the lamp sockets now in service have been manufactured with brass or copper shells, and aluminum-based lamps are used in these sockets. Aluminum in contact with the brass, and with water made conductive by atmosphere impurities, has a galvanic action. The aluminum is wasted away in this action and forms a deposit of aluminum oxide in the socket.

If the lubricant used for reducing friction would now prevent or inhibit galvanic action, this special problem would be answered. Tests so far indicate that a good application of the lubricant helps in reducing or inhibiting this galvanic action. However, in applications when the atmosphere conditions are unusually severe, the lubricant is not adequate and brass bases should be used. Better lubricants are searched for, not only for the present lamps, but to expand use of aluminum to higher wattage lamps.

The long-term objective in the lamp industry is to expand the use of aluminum just as fast as engineering skill permits. Aluminum should no longer be stigmatized by being called a substitute, and further development effort will result in its increased uses in the lamp industry.

Revised text of paper 55-262, "The New Look in Lamp Bases," recommended by the AIEE Committee on Production and Application of Light and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Electrical Utilization of Aluminum Conference, Pittsburgh, Pa., March 15–17, 1955. Scheduled for publication in AIEE *Transactions*, 1955.

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Acknowledgment is due C. W. Pearson for his extensive tests on galvanic corrosion and evaluation of lubricants, and W. E. Kotsch for the data on voltage drop on the automotive lamp test.

Stray Losses in Armature End Iron of Generators

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ASSOCIATE MEMBER

IT was recognized early in the history of synchronous machines that generator operation at high-lagging, unity, and leading power factors resulted in extra losses and comparatively high temperatures in the structural parts at the ends of the armature core. This phenomenon has come to be termed as "end heating," and is characteristic of the steam-turbine-type alternator.

During the past few years rather intensive industry-wide efforts by turbine generator designers have been devoted to increasing the specific capacity of 2-pole generators. Significant progress has been made in the design of direct-cooled generators,[1–4] and in the design of multiple-circuit and multiple-phase generators,[5] which also allow an appreciable increase in generator capacity.

The greatly increased specific capacity of these direct-cooled machines has resulted in greatly increased loadings on the generator windings. Field tests on large 2-pole generators have shown that a 10-per-cent increase in the ampere loading of a given generator will cause an increase of approximately 13 per cent in the end iron temperature.[6]

The end losses are generated by end fringing flux which passes from the ends of the rotor body and retaining rings to the ends of the armature core. This flux is produced by the winding magnetomotive forces, just as is the main air gap flux, the difference being that the permeance paths are in general longer and more complicated. The end flux rotates in synchronism with the field, and therefore sweeps past the stationary parts at the ends of the armature core at synchronous speed, inducing the eddy current losses.

The study of end iron losses has consisted of: (1) a study of the magnetic field distribution at the ends of the machine using a 3-dimensional electrolytic field mapping tank; (2) a study of the field distribution and resulting losses in the generator armature end teeth; (3) a study of the losses in various types of stator clamping flange construction; and (4) factory and field tests on models and full-scale generators.

Magnetic flux entering the end teeth of the stator core in an axial direction induces eddy currents which flow unobstructed parallel to the laminations. It has been demonstrated that a given magnetic induction entering a laminated steel body in a direction perpendicular to the laminations generates losses many times greater than the same induction entering parallel to the laminations. Eddy currents in the end teeth are largely resistance limited.

The binding bands, binding band brackets, and outside space blocks of the machines currently being built by the author's company are made from nonmagnetic steel. The eddy currents in these parts are resistance limited, since the dimensions are small in comparison with the penetration.

On the other hand, the dimensions of the stator core flange are such that with presently used materials the currents are nearly reactance limited. Therefore, the core flange eddy currents prevent most of the end iron flux from penetrating the flange and from entering the backiron. The current flowing in the flange is a small fraction of the total end winding current, the actual magnitude depending on the geometry of the end structure. Magnetic steel and cast iron flanges behave in a similar manner, except for more pronounced skin effect and higher losses than with the nonmagnetic steel construction.

It can be concluded that:

1. End iron temperature-rise margins in generators of conventional rating have been greatly increased by the introduction of split teeth in the end laminations of the stator core. Slotting the end teeth accomplishes, to a lesser degree of perfection, the same effect as laminating the core in a direction parallel to the magnetic flux. This loss reduction technique was first described, as far as the author is aware, in the foreign literature.[7]

2. It is expected that direct-cooled generators with greatly increased specific capacities currently being built by the company with which the writer is associated, will have capabilities in the underexcited region of operation similar to those of conventional units. This operation has been made possible by the development of design innovations consisting of split teeth in the end laminations of the stator core and a conducting shield over the stator core flange. The introduction of these design features will also help to maintain high efficiency in direct-cooled generators. The stator core flange shield consists of a copper shield bolted in place over the stator frame flange. This allows currents to flow in the shield, reducing the losses.

3. Progress has been made towards a complete understanding of the stray losses at the ends of the armature core in large turbine generators.

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A Continuous-Flow Moisture Device

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MOISTURE is one of the main foes of electric apparatus. In liquid-filled apparatus such as transformers, excessive moisture in the liquid can be a reflection of a similar situation in the solid insulation. The problem of accurately detecting these minute quantities of water in the liquid is an extremely important one.

In order to eliminate tedious sampling and transfer procedures when it is desired to know the water content of oil in flowing systems, a continuous-flow moisture detector was developed and evaluated. The laboratory model used for most of the work is shown diagrammatically in Fig. 1. It consists essentially of a moisture-sensitive fabric sandwiched between two metal plates with perforations. The liquid under investigation passes up through this element, and moisture from the liquid is adsorbed by the fabric in an amount proportional to the relative moisture content of the liquid. This varying amount of moisture in the fabric causes changes in the electrical resistance between the two perforated plates. Thus, by measuring this resistance, a measure of the relative moisture content of the liquid is obtained.

Preliminary studies indicated that plotting the water contents of the oils in terms of per-cent saturation gave relationships which were practically independent of temperature and oil quality. The resistance values were plotted on a log scale. Fig. 2 shows the straight line relationship obtained for a typical new transformer oil. The detector was also evaluated by measuring dissipation factor and capacitance instead of resistance. The results were not as good for these quantities. For this reason, and because of the simplicity, economy, and general portability of available instruments, the resistance measurement was adopted for further investigation.

A study was made of the influence of temperature on the results. It was found that for temperatures up to about 46 C the results gave the same straight line as was shown in Fig. 2. At 46 C some deviation from the straight line was observed. At 55 C the deviation was greater. In each case, the resistance was lower than would be expected for the per-cent saturation of water in the oil. This was attributed to a decrease in intrinsic resistance of the moisture-sensitive fabric with an increase in temperature.

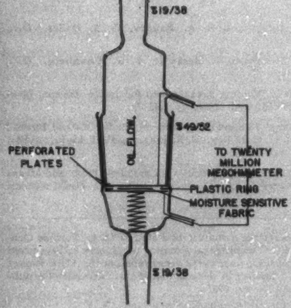

Fig. 1. Continuous-flow moisture detector

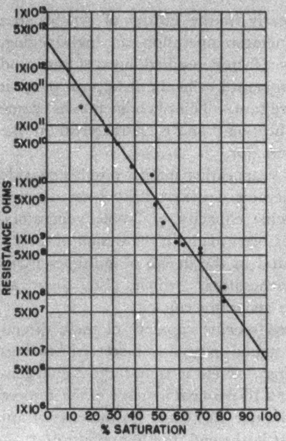

Fig. 2. Log of resistance versus per-cent saturation of water in transformer oil; using 0.003-inch fabric with 0.010-inch spacer

A brief investigation was carried out using oils from operating transformers. For an oil which was considered the poorest that would be encountered in a transformer, the maximum deviation from results obtained for new oil was 8-per-cent saturation. Some means of estimating the saturation value of used oils is essential for optimum precision. Work is being actively pursued on this problem.

In order to determine the characteristics of the moisture detector under conditions similar to a factory application and as a part of a general program designed to devise a suitable method for evaluating filter papers, a plastic laboratory model of the detector was installed on a small-scale filter press. It was found that the response of the detector was a function of the flow rate. Once the detector was calibrated for a given flow rate, the results were reproducible. A comparison of the water contents calculated from the resistance readings of the detector element with those obtained by Karl Fischer titration[1] was very favorable.

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Underground Corrosion on Rural Distribution Lines

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ANCHOR-ROD corrosion on multigrounded distribution lines has been found to occur as a result of galvanic action between copper-covered ground electrodes and galvanized steel anchor rods connected to the system neutral through uninsulated guys. This galvanic corrosion, while not observed in a majority of soils, has caused premature failures or excessively rapid deterioration of anchor rods in certain low-resistivity soils in North and South Dakota and in some other states west of the Mississippi River. Direct currents associated with the most usual corrosion reaction are shown in Fig. 1.

Galvanic corrosion is not necessarily limited to anchor rods, even though damage to anchor rods is the first symptom of trouble. Multigrounded distribution lines usually have a primary neutral conductor common with the secondary neutral at all locations where secondary or service conductors exist, and the secondary neutral is grounded to underground consumer plumbing, well casings, metallic conduit, and frames of machines utilizing electricity. Any buried metal connected to the system neutral may be involved in the galvanic reaction and, under some conditions, may be damaged or may cause damage to other underground metal connected to the neutral. The characteristics of the grounding arrangement that contribute most to galvanic corrosion are, unfortunately, the ones that are most advantageous from the standpoint of safety, lightning protection, and positive clearing of faults.

Three general types of mitigative measures appear to be useful and practical for relieving corrosion damage to anchor rods or other buried steel affected by galvanic corrosion. They are

1. Insulate buried steel from the copper-grounded neutral or replace the steel components with other materials that will not corrode excessively when connected to the copper-grounded neutral.
2. Replace copper ground electrodes with galvanized-steel ground rods.
3. Install galvanic anodes to provide drainage, and to prevent damage to the anchor rods or other buried structures.

Each of these measures has advantages and limitations that change in relative importance with local conditions.

The choice and the employment of mitigative measures against any specific corrosion problem should be based on reliable data as to the rate and extent of corrosion and the locations where most of the damage is occurring. This presents quite a problem to the distribution operator who, together with his system engineer, usually has had no previous experience in analyzing underground corrosion problems or in applying mitigative measures. The best approach is a combination of visual examinations of anchor rods possibly affected and electrical measurement of galvanic currents in guys and other connections to the neutral conductor.

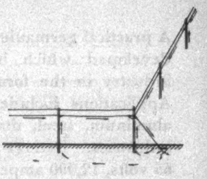

Fig. 1. Direct current flow caused by galvanic action

Studies and experience relating to underground corrosion on multigrounded distribution lines point to the following conclusions:

1. Excessive underground corrosion is generally a result of galvanic action between buried copper and steel connected to the system neutral.
2. Stray current electrolysis resulting from the cathodic protection rectifiers may cause relatively rapid underground corrosion, but should not present any serious problem if reasonable precautions are taken.
3. Galvanic corrosion of anchor rods on existing lines can be relieved by the use of strain insulators in guys or corrosion-resistant anchor rods, by substitution of galvanized steel ground rods for copper electrodes or by use of galvanic anodes. Each of these measures has advantages and limitations that change with local conditions. Steel grounding seems preferable in most cases from the standpoint of economy and minimum danger of corrosion damage to other buried structures.
4. Galvanized-steel ground rods should generally be used for replacement and new construction on all lines constructed with steel anchor rods bonded to the neutral, to minimize possibilities of excessive underground corrosion. This appears applicable to multigrounded common neutral systems generally except where strain insulators or corrosion resistant materials are being applied for corrosion prevention.
5. Anchor-rod corrosion is the first indication of galvanic corrosion on multigrounded lines with anchor rods connected to the neutral, but this should be recognized as a symptom and not necessarily the entire problem. All underground structures connected to the common neutral conductor should be considered when planning or applying mitigative measures.
6. The attitude that if some grounding is good, more is better, needs to be reconsidered from the standpoint of underground corrosion. Grounding in excess of the requirements for safety and lightning protection may be a major factor contributing to excessive underground corrosion.

Digest of paper 55-113, "Underground Corrosion on Rural Electric Distribution Lines," recommended by the AIEE Committee on Chemical, Electrochemical, and Electrothermal Applications and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Applications and Industry*, 1955.

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Application of Germanium Power Rectifiers

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A practical germanium power rectifier has been developed which is now being applied to industry in the form of a d-c power supply. Applications include its use in the chemical, aluminum, steel, titanium, and tin reclaiming industries. Ratings such as 16,000 amperes at 65 volts, 12,000 amperes at 130 volts, and 40,000 amperes at 24 volts are being manufactured.

ALTHOUGH THE METAL GERMANIUM is not a recent discovery, the bulk of research and development on this material has been done in the recent past. So it can be said that the discovery of the important uses of germanium has been made during the past decade. Anything that promises a revolutionary change in the field of electronics immediately becomes important because electronic equipment now plays such a vital part in industrial development as well as in everyone's life. Such wide publicity has resulted in many people using the terms in a conversational way without realizing the exact meaning or the wide range of possible applications.

Several large companies have devoted much time and money to research on the possible uses of germanium. As some of this development work progressed in the research laboratories of the General Electric Company, it was only natural that some of the engineers should begin to think of the possibilities of this metal in a direction other than electronic applications. Consequently, one branch of the development was directed toward power rectifiers. In due course a practical germanium power rectifier element was developed and has now been applied to industry in the form of a d-c power supply.

For many years the well-known copper oxide and selenium rectifiers have been important where d-c power is needed in moderate quantities for industrial plants. Now the germanium power rectifier takes its place beside the others and promises to replace them in many applications.

GERMANIUM POWER DIODES

THE FIRST LOOK at this new power rectifier is impressive because of the rectifier's small physical size compared to other metallic rectifiers. See Fig. 1. Germanium is not a plentiful metal and its present cost is quite high. Fortunately a very small quantity of the metal will perform a large rectifying job. Germanium is a gray-colored crystalline metal, hard and brittle, with a melting point slightly below 1,000 C. One source of the metal is a by-product of the silver and zinc mining industries. It must be carefully refined so that the final product is in single crystal form. The pure single crystal material is produced as a long cylinder, shaped like a cigar, with the diameter being controlled by the speed and temperature of processing. The material is then sliced into wafers about 0.020 inch thick and about the diameter of a dime. But this wafer does not yet have all of the required qualities of a rectifier. Although a complete chemical explanation of the atomic structure required to produce rectifying properties is quite

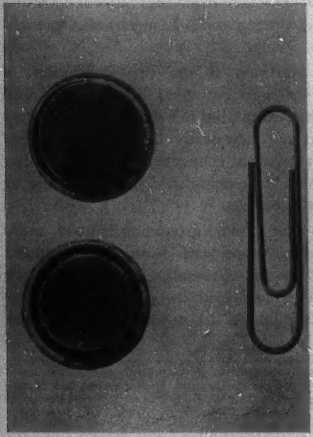
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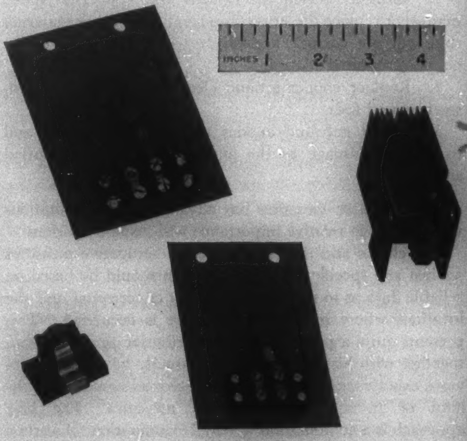
Fig. 1 (left). Germanium rectifier element. Fig. 2 (right). Germanium rectifier elements mounted



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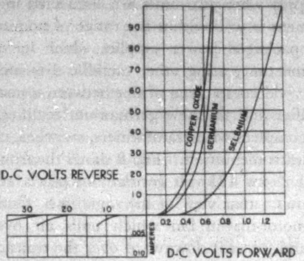
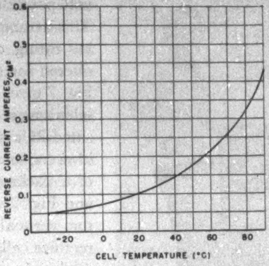




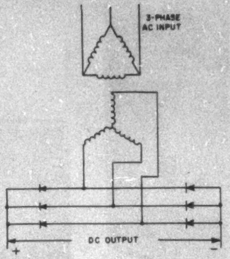


Fig. 3 (left). D-c characteristics of typical metallic rectifiers per 1-square-centimeter active area. Fig. 4 (center). Reverse current-temperature characteristic at rated voltage. Fig. 6 (right). Double-way rectifier unit of 250-ampere 65-volt direct current output—one of the standard connections

involved, the designation *p*-type and *n*-type germanium is currently being used to describe the structure. This simply means that some impurity or unbalance of the atomic structure is necessary to produce free electrons. Experiment has proved that alloying with indium produces *p*-type germanium and alloying with antimony produces *n*-type germanium. The actual rectifying element is made in the form of a sandwich with the thin wafer of germanium placed between a layer of indium and a layer of antimony. This sandwich must be carefully heat-treated to produce the desired atomic structure which permits easy current flow (in the conventional sense opposite to electron flow) from *p* to *n*. This is a critical step in the process; close control of time and temperature is essential for uniformity of electrical characteristics.

RECTIFIER CHARACTERISTICS

The relative size and physical arrangement of the dime-sized wafers already described is indicated in Fig. 2. The small physical size will be recognized as a distinct advantage and it is interesting to make a comparison between this cell and those of other metallic rectifiers.

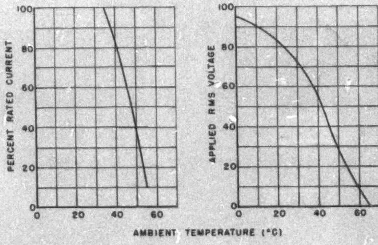
The ratio of forward to reverse resistance is in the order of 1 to 400,000 at the area of optimum rating, which far exceeds the ratio of other metallic rectifiers. Obviously the small size is advantageous only if the material can be worked at a high current density. Fig. 3 indicates the relative current density of the three principal metallic rectifiers: germanium, copper oxide, and selenium. Note that for germanium the scale is read in amperes per square centimeter, while for the others it is milliamperes per square centimeter. This illustrates that the germanium cell is operated at a current density almost 1,000 times greater than copper oxide. To make a more simple comparison, one of these dime-sized wafers, when properly cooled, is capable of rectifying as much as 3 kw. At this point it is evident that the small size offers some problems as well as advantages, mainly in the ability to make the physical connections which will handle relatively large currents. Another problem is that of effectively removing the heat generated in this very small device.

Like other metallic rectifiers, germanium has a negative temperature characteristic. Forward losses are a function of load current and reverse losses are a function of inverse voltage. Both losses cause a cell temperature rise which, in turn, changes cell resistance to modify the losses further. Reverse losses increase rapidly as the temperature rises because the reverse current change is exponential. Fig. 4 indicates how reverse current changes with temperature. The heat must be dissipated from a small area very rapidly and the radiating fins with forced air or liquid immersion have proved the most effective method so far.

The normal full-load temperature rise of the cell is 30 C over a 35-C ambient. Experiment has determined the derating curve for higher ambient temperature. The derating can be done either by current or voltage. Fig. 5 shows this relationship.

ELECTRIC CONNECTIONS

Germanium rectifier cells can be connected for single-way or double-way, single-phase and 3-phase operation. Individual cells can be operated at a voltage con-



A

B

Fig. 5. Current rating at various ambient temperatures: *A—Current derating at rated voltage; B—Permissible operation voltage of nominal 65-volt rms cell at various temperatures when equipment is operated at rated current*

Essentially full text of paper 55-138, "Application of Germanium Power Rectifiers," recommended by the AIEE Chemical, Electrochemical, and Electrothermal Applications Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Published in AIEE *Applications and Industry*, March 1955, pp. 48–52.

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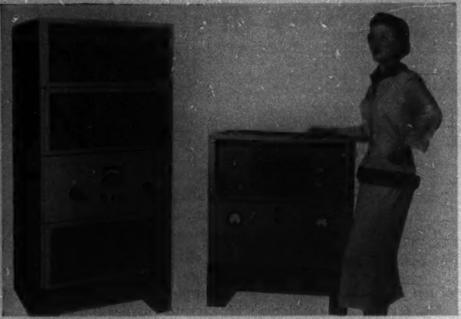


Fig. 7. Size comparison between germanium and selenium units

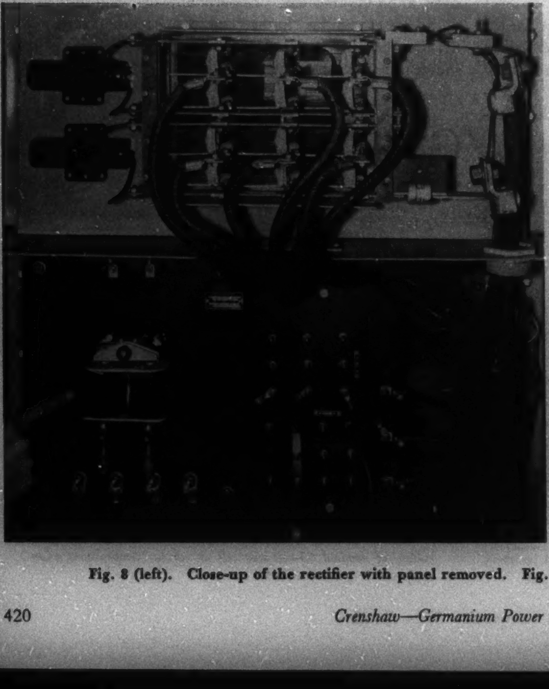
siderably higher than is customary with other metallic rectifiers of equivalent rating. One of the standard connections is shown in Fig. 6. This is a standard double-way 3-phase rectifier connection. Six individual cells connected in this manner have a rating of 225 amperes as 65 volts direct current. This is a surprisingly high rating for six of these relatively small germanium cells and is one of the distinct advantages. Such a self-contained power supply can be connected on the d-c output side in series or parallel with other equivalent units to form almost any combination and rating of power supplies required for industry. This voltage rating lends itself to providing the customary 125-volt power supply when two units are connected in series. This arrangement is well within the range of nominal 25-kw rating of packaged power supplies which have been offered for some time, using other metallic disk rectifiers. Fig. 7 gives a vivid comparison of size between a packaged selenium rectifier and the new germanium rectifier, both rated 25 kw, complete with transformers, switches, cooling blowers, and instrumentation. Fig. 8 shows the front view of a packaged 25-kw 125-volt germanium power rectifier and Fig. 9 shows a rear view of the same unit, displaying the vertical motor-driven fan which pulls air over the rectifier cells and forces it downward over the transformer, discharging out the bottom of the cubicle.

To summarize, the principal advantages of germanium power rectifiers over other metallic types are: 1. high efficiency; 2. low regulation; 3. good stability; 4. very small reverse current; 5. high inverse voltage rating; and 6. small physical size. Fig. 10 shows a typical efficiency and regulation curve.

INDUSTRIAL APPLICATION

THE FIRST PURCHASER of General Electric germanium power rectifiers was the Metal and Thermit Corporation. This company reclaims tin from tinplate scrap by the electrolytic method, which requires a considerable amount of direct current at a potential in the order of 115 volts. The load is constant.

Recently this company decided to replace an old motor-generator set. After comparing motor-generator sets, mechanical rectifiers, and other metallic disk rectifiers, a



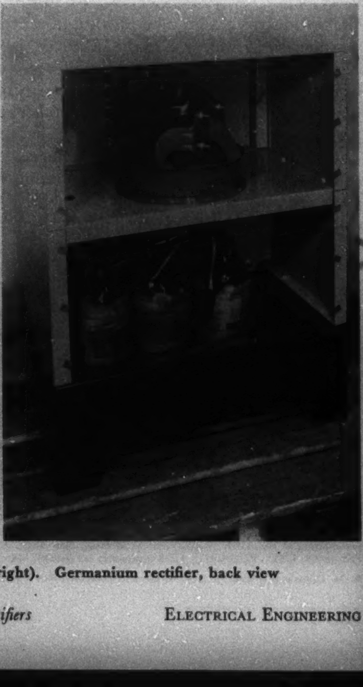


Fig. 8 (left). Close-up of the rectifier with panel removed. Fig. 9 (right). Germanium rectifier, back view decision was reached to give this new germanium power rectifier a chance to prove the advantages claimed for it. As well as being competitive in first cost, germanium has the advantage of high efficiency, easy installation, quietness of operation, and very little maintenance.

A group of four 25-kw packaged power supplies, as described previously, were installed. Fig. 11 shows the installation. These units are connected in parallel to a common d-c bus which will supply a nominal rating of 800 amperes at a voltage up to 125 volts direct current.

CHARACTER OF THE LOAD

The chemical process is beyond the scope of this article; however, a brief explanation of electrical characteristics will be helpful in understanding the application. In common with most electrolytic processes, the internal resistance of the circuit is quite low. It follows that the initial applied voltage must be quite low to limit inrush current to a reasonable value. A voltage in the order of 25 per cent of final full-load voltage is a safe value for use with the rectifier.

As current begins to flow through the electrolyte, a back electromotive force (emf) is produced. This counter voltage rapidly rises to a value equal to the reduced applied voltage. Thus, the inrush current is quickly reduced to practically zero. The applied voltage may now be increased in fairly large steps without causing further excessive inrush current, provided the continuity of the circuit is maintained. The back emf continues to rise as the applied voltage is increased, finally reaching a maximum value at about 80

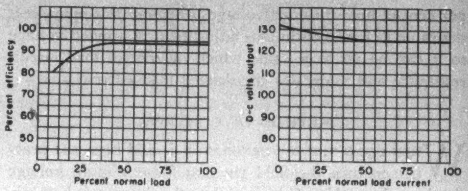


Fig. 10. Typical efficiency and regulation characteristic with the per cent normal load versus per cent efficiency and the per cent normal load current versus the d-c output

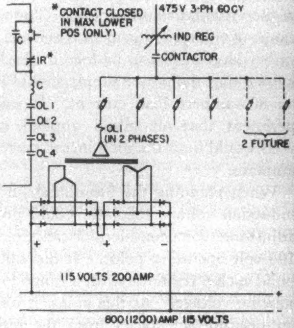


Fig. 12. Diagram of connection of germanium rectifier power system

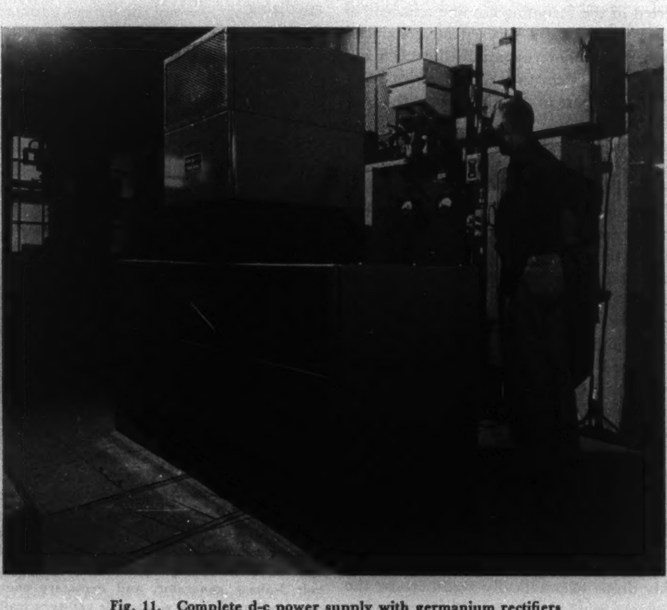


Fig. 11. Complete d-c power supply with germanium rectifiers

per cent of final full-load voltage. Beyond this point, it is desirable to have continuous adjustment of applied voltage so it can be set at a value which overcomes load circuit resistance and maintains the desired load current.

METHOD OF CONTROL

When using the d-c generator it had been the practice to turn the field rheostat for minimum voltage (in the order of 35 volts), then close the d-c circuit breaker. From the characteristics of the process previously described, it can be seen this practice would cause a sudden current inrush which would taper off to practically zero as the back emf builds up. With the rectifier, the problem is a little different in that it is desirable to limit inrush current for better protection of the cells, as well as to minimize tripping of the instantaneous overload. The need for a rather wide range of voltage adjustment is evident, although fortunately rather large steps can be used at the lower values. It was known that the power supply should be about 100 volts for an 800-ampere load current. It was determined by experiment that an initial applied voltage of about 25 volts would limit the total inrush current to the order of 200 amperes.

When planning the installation, it was decided that an induction voltage regulator could provide smooth voltage adjustment for a considerable range either side of the normal 100-volt operating point. It did not seem economical to build such a regulator with a range to provide the required starting voltage. At this point, it was discovered that the autotransformer starter from the retired motor-generator set drive motor would be available. By opening the Y of this autotransformer, three series reactors are available and these are inserted in the incoming a-c line adjacent to the voltage regulator to provide a very effective reduced voltage for starting. Fig. 12 shows essentially the schematic connection of the power system used. The series reactors are not shown here, but are located just below the contactor.

The voltage regulator is rated 475 volts, 154 amperes, making it suitable for six 25-kw rectifier units. It provides continuous manual control 25 per cent above and below rated voltage. This range gives 73 volts minimum to 122 volts maximum at the rectifier output terminals.

Proper sequence for start-up is assured by interlocks in the main contactor control circuit. The fans must be running, overloads reset, and voltage regulator at the minimum position before the main contactor can be closed. The manual short-circuiting contactor around the series reactor is always released by its "no voltage release coil" when the main contactor is open.

The first operation is to close the d-c load circuit breaker; then power is applied to line by push-button control which closes the main contactor. This applies the minimum alternating voltage to the rectifiers, resulting in about 25 volts direct current at the load. This voltage suddenly applied to the load causes a momentary inrush in the order of 200 amperes total current if the line has been idle for a period long enough for the back emf to disappear. The current quickly drops to practically zero because the back emf soon equals the applied voltage. Short-circuiting of the reactor raises the supply voltage to 73 volts direct current, again causing a current inrush in the order of 200 amperes total. This current rapidly decreases to practically zero as the back emf quickly builds up to a new value. Next the d-c bus voltage is increased by raising the voltage regulator. At about 80 volts on the d-c bus, the load ammeter begins to show steady-state current flow through the load, indicating that the maximum back emf has been reached. The operator continues to increase the d-c bus voltage by means of the voltage regulator until the desired load current is reached. It has been found that 101 volts produces a load current of 800 amperes which is satisfactory operation, leaving ample range in the regulator in either direction to provide for minor changes in load characteristics.

Operating temperatures of the rectifier cells have been measured at several points under normal load conditions. With an ambient of 32 C, the highest total temperature observed is 49 C.

Refer again to Fig. 11 which shows this installation at work. The four units are arranged in such a manner that two more units can easily be added to bring the total rating to 150 kw, the equivalent of the retired motor-generator set.

A similar germanium rectifier installation has been in operation for several months in a General Electric plant. Several other complete power supply equipments are on order for use in the chemical, aluminum, steel, and titanium industries. Ratings such as 16,000 amperes at 65 volts and 12,000 amperes at 130 volts are being manufactured for these industries. An equipment rated 42,000 amperes at 24 volts has recently been installed for aluminum anodizing.

Emergency Mobile Electric Set

Mobile generator-set employed by Philadelphia Electric Company for temporary or emergency power during construction or maintenance periods. Built by Giles and Ransome, Inc., the set consists of a 500-hp 1,200-rpm 12-cylinder Caterpillar diesel engine, a General Electric Company 375-kva 80-per-cent power factor 4,160-volt 3-phase generator, and necessary control equipment, all mounted in a Gramm single-axle van-type trailer

Detection of Grounds in Generator Field Windings

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ONE facet of a-c generator protection that has not received sufficient study is that of detecting grounds in the field windings. There are many schemes available and in use for detecting field grounds, but all of them have some weakness or shortcoming.

There are two factors that make the detection of generator field grounds difficult. First, the field circuit is normally isolated from ground, and even with constant voltage applied, the potential between the conductor and the rotor iron is variable, depending on the specific location in the winding. Under normal conditions, the capacitance to ground of the field winding forces a distribution of voltage so that the potential between each slip ring and the rotor iron is one half of the applied voltage, and the potential to iron at the electric center of the field winding is zero.

The second factor is found in the bearings of the machine. The generator designer provides insulation in both bearing pedestals so that a path for the flow of shaft current through the bearing pedestals and the bedplate does not exist. The reason for this is the damaging effect that current, even though very small, can have on the bearing surfaces. The turbine bedplate is generally a part of the station ground, and its bearing pedestals are available to connect the bedplate to the shaft electrically. Unfortunately, this connection is a poor one, because the bearing contains an oil film that can be an insulating barrier for low voltages and provides a path of low and variable conductivity at higher voltages. The conducting qualities of the bearing oil film depend greatly on the purity of the oil, clean oil being a poorer conductor than oil containing dirt or moisture.

Thus, one can conclude that the shaft and rotor of a turbine generator may be electrically isolated from the bedplate and station ground by the insulating properties of the bearing oil film.

The lamps, voltmeters, or relays used to detect field-winding grounds are normally connected between the slip-ring brushes and the station ground. Even with the field winding solidly connected to the rotor iron, operation of the ground detector is dependent on the circuit between the shaft and the station ground, which includes the bearing oil film. It is for this reason that the ability of these ground indicating schemes to detect field-winding grounds is open to question.

All of the ground detector schemes now in use have a common shortcoming in that they depend on conductivity through the bearing oil film to cause operation. No scheme offers a positive solution to the problem.

Experience with these schemes has varied. Some operations have been reported, but whether the detector indicated a ground at the instant it occurred is always debatable. It is conceivable that a field-winding ground might exist for days or weeks before the bearing oil film conductivity becomes high enough to permit operation of the ground detector. It is also conceivable that the detector might never operate.

In any event, it is extremely important that operators realize that the lack of a ground detector indication does not necessarily mean that there is no ground on the winding. The ground detector must be treated as a device that may indicate a ground, but some more positive means must be used to detect grounds.

It can be concluded that:

1. All ground detector schemes now available and in use rely on the conduction of current through the bearing oil film for effective detection of grounds. The bearing oil film has variable insulating properties depending on the quality and cleanliness of the oil and, in many cases, may prevent the detector from performing its function.
2. The use of a shaft slip ring to by-pass the bearing oil film is not recommended. Because of the glaze or film that will develop on the surface of the slip ring, the bearing oil film is apt to be more conducting, in which case the purpose of the shaft slip ring is defeated. In addition, the expense and difficulty of finding a location on the shaft for the slip ring and brush assembly are not justified by the questionable advantage gained.
3. Alternating voltage method is not recommended because of the danger of establishing capacitive leakage current through the generator bearings. This current can be established even though no field ground exists. Also, part of the ground insulation is overstressed, caused by the a-c component of voltage added to the normal exciter voltage.
4. Even when the alternating voltage is rectified into direct voltage, the condition of overstressing the field insulation continues to exist.
5. The scheme using a voltage divider bridge with one leg of the bridge being a nonlinear resistor, that will shift the zero point of ground measurement as the exciter voltage varies under regulator control, seems to offer the best over-all protection.
6. In the final analysis the insulation resistance of the winding should be determined or some overvoltage means should be used to determine the insulation condition at every shutdown period of the generating equipment, to insure that no undetected grounds in the field winding exist.
7. Movement of the rotor coils caused by rotational forces may contribute to establishing a field-winding ground. Therefore, an insulation check with the machine running at normal speed is desirable. The bearing oil film and pedestal insulation should be by-passed with a jumper.

Digest of paper 55-125, "Detection of Grounds in Generator Field Windings," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Vibration in 2-Pole Induction Motors

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VIBRATION and noise in a 3-phase 2-pole a-c motor quite often are characterized by a pulsation or "beat" in the amplitude. That is, the amplitude of the vibration and noise increases and decreases at a uniform frequency which is related to the slip of the rotor. In many applications, these pulsations are not detrimental to the performance of the machine, but they do have an adverse psychological effect upon anyone in the vicinity, because a pulsating noise is much more noticeable than a steady one.

Two types of pulsation are encountered the most frequently. The most common varies at two times slip frequency; the second varies directly with slip. These pulsations are of the order of from 1/2 to 10 cycles per second, depending on the slip of the rotor and the type of pulsation. A normal human ear cannot hear vibrations much under 15 cycles per second, but these pulsations can definitely be heard. Therefore, it is reasoned that the pulsations are not a single frequency, but must be the result of co-operation between two different frequencies at least one of which is in the audible range.

Fundamentally, low-frequency pulsations can be caused in two different ways. First, the amplitude of a given vibrational force wave may be modulated by another vibrational force of a different frequency. A typical sinusoidally modulated wave is shown in Fig. 1. The amplitude of the carrier wave increases and decreases uniformly or pulsates as dictated by the modulating wave, but its frequency remains constant.

Second, if two vibrational driving forces exist simultaneously which have approximately the same frequency, they alternately aid and buck one another causing the phenomenon of beats and the frequency of the pulsation is the difference between the two frequencies. The addition of two sine waves with slightly different frequencies results in a curve with an envelope exactly the same as in Fig. 1.

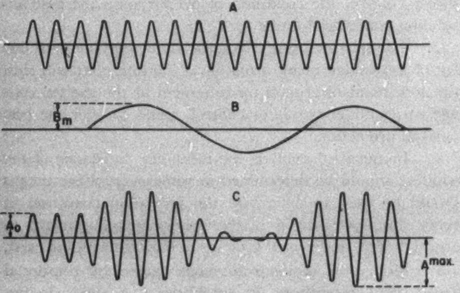

Fig. 1. Sinusoidally modulated wave

A—Carrier wave unmodulated; B—Modulating wave ($7\frac{1}{2}$ *cycles*); *C—Modulated wave*

In any 2-pole a-c machine, many vibrational driving forces, both mechanical and electromagnetic, exist simultaneously and can co-operate to produce both phenomena just described. All a-c motors have a twice line frequency driving force caused by the inherent radial magnetic forces. It is more prominent in 2-pole machines because of the comparatively greater distance between poles. If the rotor is eccentric, there is a point of minimum air gap which revolves at rotor speed. In one revolution of slip, this minimum air gap comes under the influence of a pole twice, and so the frequency of the unbalanced magnetic force is twice slip frequency. As a result, the second harmonic driving force is modulated at twice slip frequency. Other mechanical dissymmetries, as a bent shaft, or dynamic unbalance, combined with a weak shaft will also cause a revolving minimum air gap. Electrical dissymmetries in the rotor cause the same frequency modulation.

The phenomenon of beats is caused by the combination of twice line frequency driving forces and twice running frequency forces which differ by two times slip frequency. In addition to the inherent radial forces, such things as the stator bore being elliptical or uneven air gaps amplify the twice line frequency forces. The twice running frequency forces are caused mechanically by factors like a shaft with noncircular cross sections or elliptical bearings.

Another factor which causes a beat is the space harmonics in the main flux wave. The frequency of the voltage induced in the rotor by the fifth and seventh harmonics differs numerically by twice slip frequency. Thus a point on the rotor sees two revolving fields which alternately aid and buck one another, causing a torque pulsation. Other combinations of harmonics such as the 11th and 13th, 17th and 19th, etc., also beat at two times slip frequency and so have the same effect.

Another type of pulsation is the result of a modulation of running frequency vibrations by an unbalanced magnetic force. If the rotor is not centered, causing uneven air gaps, then the resulting unbalanced magnetic force alternately adds to or subtracts from the dynamic unbalanced force. The frequency of this pulsation can be slip frequency, or a little less than slip frequency, depending on the slip.

A perfectly symmetrical machine thus would not be afflicted with vibration pulsations, although it still might vibrate. In order to eliminate the pulsations, the stator bore, air gaps, rotor, and shaft must be made as accurate and uniform as practical. Also, the natural frequency of the shaft and stator core must be kept away from running frequency or twice line frequency. Finally, a stator winding which suppresses space harmonics should be used.

Digest of paper 55-133, "Vibration in 2-Pole Induction Motors Related to Slip Frequency," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1955.

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Coaxial Cavity Filters for Multiplexing of 900-Mc Radio-Relay Systems

M. H. KEBBY

Coaxial cavity band-pass filters of one or more sections in tandem have been developed to provide for simultaneous application to a single antenna of two or more radio transmitters and receivers operating in the 900-mc range. Considerable savings can be realized in equipment cost for multichannel radio systems.

ANTENNAS used with microwave radio systems are normally capable of handling efficiently a much wider band of frequencies than is required for a single unidirectional group of communication channels. In this respect, antennas can be compared to open-wire lines or cable pairs, both of which are capable of transmitting a wider frequency band than is occupied by a single telephone channel or group of channels in a particular part of the frequency spectrum. Just as physical lines are commonly multiplexed to use fully their transmission band capabilities, so are microwave antennas used for simultaneous transmission and reception of more than one group of radio channels. Physical lines are multiplexed by using coil–capacitor or, in some cases, crystal filters to separate the various frequency bands involved. Although such conventional filters are not practical at microwave frequencies, other types of frequency selective devices can be used.

In the 900-mc region, coaxial cavities are the most practical and economical type of filters, largely because of their excellent electrical characteristics and convenient size. Such accessory equipment is used in a recently developed Lenkurt type *72B* radio system. Although presently available designs use short-circuited quarter-wave coaxial sections tuned for operation only in the 900-mc band, similar filters are practical for other frequency ranges.

In possible applications of type *72B* radio equipment, up to three parallel radio circuits may be required in the 900-mc band (890 to 936 mc). A frequency allocation permitting such operation is shown in Fig. 1. Filters have been designed with sufficient selectivity to permit a minimum separation of 12 mc between any transmitter and receiver operating on the same antenna. Minimum separation between two transmitters or between two receivers on a single antenna is 6.3 mc.

Coaxial cavity filters acting as multiplexers, diplexers, and multidiplexers have been developed for the following equipment combinations:

1. One transmitter and one receiver: diplexer
2. Two transmitters } : multiplexers
3. Two receivers } : multiplexers
4. Three transmitters } : multiplexers
5. Three receivers } : multiplexers
6. Two transmitters and two receivers: multidiplexer

COAXIAL CAVITIES AS R-F FILTERS

COAXIAL cavity filters consist of one or more short segments of coaxial transmission line with each segment corresponding to an individual mesh of a conventional coil–capacitor filter. Each line section is effectively a quarter wave long at the center of the passband (referred to as the resonant frequency); it is short-circuited at one end and open-circuited at the other, with coupling loops provided for the input and output connections. In the vicinity of resonance, the impedance–frequency characteristics of such a line are equivalent to those of a lumped-constant parallel-resonant circuit with an equivalent Q. Generally, the desired attenuation characteristics of the r-f filter lie in the frequency range of about 5 per cent above and below the resonant frequency. Therefore, within this range, standard response curves relating bandwidth and Q derived for lumped-constant circuits may be used.

The frequency of resonance f of a transmission line in megacycles is given approximately by: $f=246n/L$, where n is the number of quarter-wavelengths along the line and L is the line length in feet. In an r-f filter, a line is ordinarily used at its lowest possible (fundamental) resonant frequency, in order to have the greatest possible frequency separation between higher-order resonant modes. With a short-circuited quarter-wave line the closest resonant frequencies occur at odd multiples (3, 5, 7, etc.) of the fundamental frequency, while with a half-wave open line the higher order modes are even multiples of the fundamental. In addition, the quarter-wave line is shorter and occupies less space, an important consideration in the uhf and lower microwave spectrum. Thus, a quarter-wave line was selected for this design.

Coupling Methods. Various arrangements can be used for coupling energy into and out of tuned cavities. The coupling may be either magnetic or electric. Coupling to the magnetic field is most effective near the short-circuited end of a quarter-wave line where the current density is greatest, while coupling to the electric field is most effective near the open-circuited end where the highest voltage

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Essentially full text of paper 55-200, "Coaxial Cavity Filters for Multiplexing of 900-Mc Radio-Relay Systems," recommended by the AIEE Committee on Radio Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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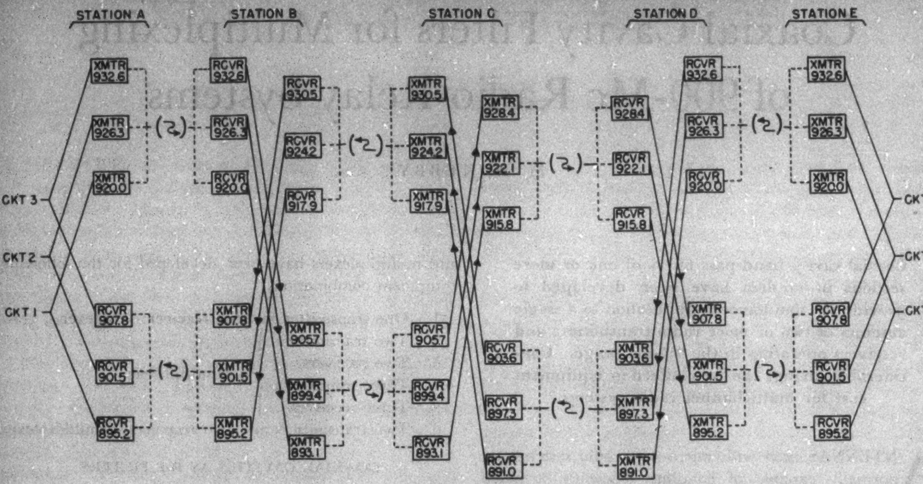

STATION A
STATION B
STATION C
STATION D
STATION E
XMTR 932.6
XMTR 926.3
XMTR 920.0
RCVR 907.8
RCVR 901.5
RCVR 895.2
RCVR 932.6
RCVR 926.3
RCVR 920.0
XMTR 907.8
XMTR 901.5
XMTR 895.2
RCVR 930.5
RCVR 924.2
RCVR 917.9
XMTR 905.7
XMTR 899.4
XMTR 893.1
XMTR 930.5
XMTR 924.2
XMTR 917.9
RCVR 905.7
RCVR 899.4
RCVR 893.1
XMTR 928.4
XMTR 922.1
XMTR 915.8
RCVR 903.6
RCVR 897.3
RCVR 891.0
RCVR 928.4
RCVR 922.1
RCVR 915.8
XMTR 903.6
XMTR 897.3
XMTR 891.0
CKT 3
CKT 2
CKT 1
(2)

Fig. 1. Frequency allocation for the operation of three type 72B radio systems over one path

gradient exists. Magnetic coupling may be obtained by placing a small loop of wire or ribbon, connected to a coaxial transmission line, in the cavity. Electric coupling is usually accomplished with a small capacitive probe, formed by extending the center conductor of the coaxial transmission line into the cavity.

Magnetic loop coupling has been chosen in the present design. The loops protrude through the short-circuiting plate of the coaxial cavity. Input and output loops are placed on opposite sides of the center conductor to provide minimum direct magnetic coupling between the loops. Such coupling between loops would tend to reduce the selectivity of the filter.

The effect of coupling loop position may be seen by considering an approximate equivalent circuit of a cavity filter near resonance (Fig. 2). The loop inductances L_1 and L_2 will be tuned out by the resonant circuit L_0 and C_0; however, they should be kept as small as possible to prevent altering of the impedance characteristics of the resonant circuit.

The mutual coupling M_1 and M_2 between the loops and the resonant circuit is dependent upon the loop areas and their position and orientation in the magnetic field. The input impedance at resonance is dependent primarily upon the relationship between M_1 and M_2 for a given load impedance. Generally, M_1 is made equal to M_2, so that at resonance, the input impedance is approximately equal to the load impedance. At other frequencies, the input impedance is dependent more upon the impedance of L_0 and C_0, which, of course, drops as the frequency deviates from resonance. This, in turn, results in an extremely low input impedance which is practically independent of the load impedance.

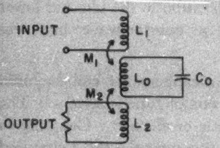

INPUT
L_1
M_1
L_0
C_0
M_2
OUTPUT
L_2

Fig. 2. Equivalent circuit of coaxial cavity filter near resonance

The rate at which the input impedance drops as the frequency deviates from resonance (selectivity of the filter) is dependent upon the loaded Q of the resonant circuit; this is determined primarily by the value of M_2 (for a fixed load impedance). Thus, the selectivity of the filter may be changed by altering the coupling, a relatively simple matter with rotatable coupling loops.

Insertion Loss. Filter losses at resonance are primarily caused by dissipation and mismatch. Dissipation within the filter may be kept to a minimum by using a high-conductivity material on the inside surfaces of the cavity. A good low-impedance short circuit at the short-circuited end of the line is also important. As in a lumped-element circuit, dissipation results in a finite unloaded Q. The magnitude of the dissipation loss generally lies between 0.25 and 2 db and is given by[1]

$$\text{Dissipation loss (db)} = 20 \log \frac{Q_u}{Q_u - Q_l}$$

where Q_u is the unloaded Q and Q_l is the loaded Q.

The magnitude of the mismatch loss is determined primarily by the relationship between input and output coupling factors (M_1 and M_2 in Fig. 2) and the load and source impedances. It is generally less than 0.1 db.

Practical Filters. A typical quarter-wave short-circuited coaxial cavity filter section is shown in Fig. 3. The cavity has an outside diameter of 2 inches, a length of approximately 6 inches over-all, a characteristic impedance of approximately 80 ohms, and an unloaded Q of greater than 2,000. The length of the center conductor is adjustable to allow tuning from 890 to 960 mc.

Fig. 4 shows a set of measured curves giving the attenuation versus frequency characteristics of a single filter section. Curve *A* was taken with the coupling loops set in a position of maximum coupling; insertion loss at the center frequency was 0.25 db. Curve *C* was taken with the coupling loops set to allow very little coupling; insertion loss for this position was 1 db. Curve *B* was taken with the loops in an intermediate position. The maximum attenuation for the condition of the loops adjusted for maximum coupling is about 32 db, and is limited by the direct magnetic coupling between the input and output loops.

MULTISECTION FILTERS

Several coaxial cavities are cascaded to provide more attenuation outside the passband than is possible with a single filter section. Selectivity to some extent is controlled by the degree of coupling. As the coupling is reduced, the passband may become intolerably narrow and the filter may become too critical to adjust. Under such conditions, it is necessary to add one or more sections to obtain adequate selectivity.

The most convenient method of coupling between filter sections is through transmission lines of an odd multiple of quarter waves in length.[2] This length is not critical, however, as shown in Fig. 5 where the attenuation characteristics are plotted for several lengths of coupling line.

Fig. 6 shows a set of curves measured with one, two, and four filter sections in tandem. Each section was adjusted to provide the same attenuation and insertion loss.

The total insertion loss of the filter sections in tandem at resonance is the sum of the insertion losses of the individual filters. Note that the attenuation for a given frequency outside the passband is greater than that of the sum of the attenuations of the individual filters. This is because of the increased mismatch loss created by the impedance transforming properties of a quarter wavelength of transmission line.

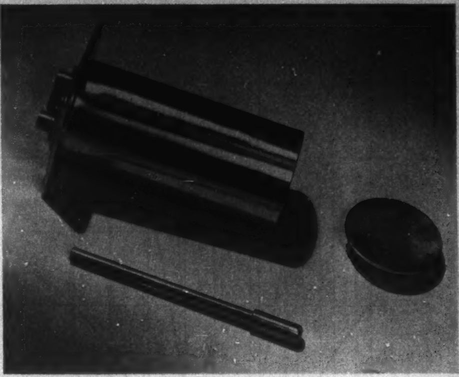


Fig. 3. 900-mc coaxial cavity filter

At a given frequency outside the passband, the input and output impedances of the filters are less than the characteristic impedance of the coupling line. Because the load impedance Z_1 of the coupling line is less than its characteristic impedance Z_0, the input impedance Z_i to the line will be greater than its characteristic impedance, or equal to: $Z_i = Z_0^2/Z_1$. With a zero-length coupling line (or a line a multiple of half-waves in length), the mismatch loss would be proportional to the ratio Z_0/Z_1; however, with a quarter-wave coupling line, the mismatch loss is proportional to Z_i/Z_1 which is equal to Z_0^2/Z_1^2. Loss at the passband frequencies is not affected, since the line is terminated in its characteristic impedance.

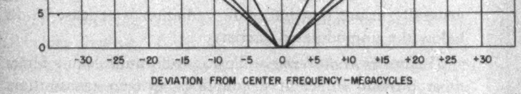
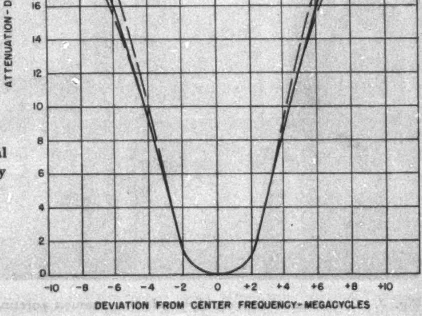


Fig. 4 (above). Attenuation of a single-section coaxial cavity filter for several coupling conditions. Fig. 5 (right). Attenuation of a 2-section coaxial cavity filter for various lengths of coupling line between filter sections



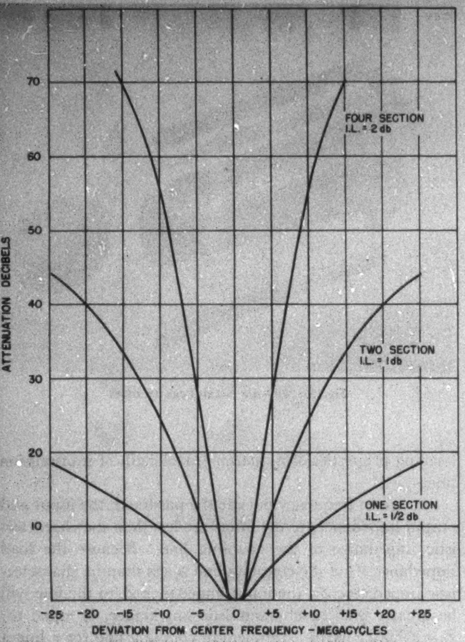


Fig. 6. Attenuation for one, two, and four filter sections in tandem

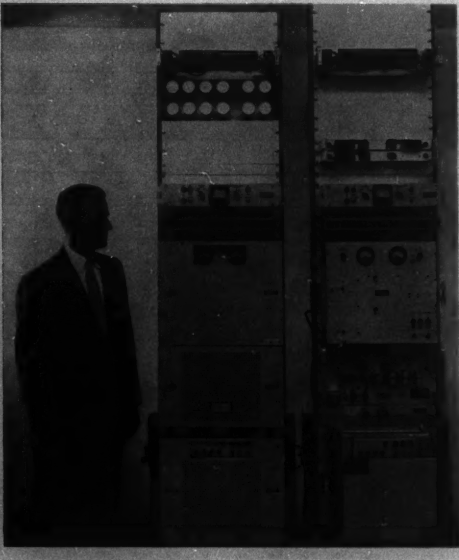


Fig. 7. Two transmitters multiplexed on a common antenna

APPLICATIONS

Coaxial cavity filters are presently used with the type *72B* radio system for: (1) receiver preselection; (2) receiver multiplexing; (3) transmitter harmonic suppression; (4) transmitter multiplexing; (5) transmitter–receiver diplexing; and (6) multidiplexing.

Receiver Preselection. When the first stage of a superheterodyne receiver is a mixer, some form of filtering must be provided between the antenna and mixer to prevent extraneous signals from entering the mixer and causing interference. A 2-section filter having the attenuation characteristics shown in Fig. 6 is generally used on the type *72B* receivers for preselection. In applications where extremely close spacing of transmit and receive frequencies is necessary, a 4-section filter may be used to provide the required additional selectivity.

Receiver Multiplexing. When used to multiplex more than one receiver on an antenna, the coaxial cavity filters must furnish sufficient isolation between receivers to prevent loading of the antenna at frequencies other than the operating frequency of the individual receivers. When coaxial cavity filters are used for multiplexing, they also act as receiver preselection filters, since the requirements for preselection are less severe than for multiplexing. In many cases, sufficient isolation could be provided by a 2-section filter between each receiver and the common line; however, because of the multiplicity of transmitters which usually exists at a location where receivers are multiplexed, the possibility exists of spurious frequencies, causing objectionable interference in the receiver. For this reason, the greater selectivity provided by 4-section filters is desirable.

The arrangement commonly used to multiplex more than one receiver on an antenna requires the 4-section filter in the front end of each receiver. The total insertion loss of each filter is 2 db. The filter input impedance is very low off resonance; therefore, to make the off-resonant input impedance very high (looking at the filters from the junction), the line interconnecting the filters and the junction block is made three quarters of a wavelength. At the resonant frequency, the line input impedance at the junction is almost equal to the receiver input impedance.

Transmitter Harmonic Suppression. A single-section filter is generally used in the transmitter to provide the necessary suppression of harmonic radiation. A filter having attenuation characteristics, as shown in curve *A* of Fig. 4, will generally insure that harmonic radiation is at least 70 db below the unmodulated carrier.

Transmitter Multiplexing. Transmitter multiplexing filters must provide sufficient decoupling between transmitters to prevent the creation of intermodulation products of a disturbing nature in the final transmitter stage; in addition, they must allow loading of the antenna only at the operating frequency of each transmitter. Filters which provide the necessary attenuation for multiplexing automatically provide the required harmonic suppression, since the latter requirement is less severe.

It has been found that at least 25 db of isolation is required between type *72B* transmitters to insure that spurious products will be more than 75 db below the transmitter unmodulated carrier. This requirement is particularly severe in the case where three parallel links are in operation with transmitters equally spaced in frequency. Under these conditions, the third order $(2F_c-F_h)$ or $(2F_c-F_l)$ product between the center and high (or center and low) frequency transmitters falls directly on the low (or high) frequency transmitter. This product, if it reaches the receiver with sufficient intensity, would result in an objectionable beat frequency which could cause interference in a carrier-derived voice channel.

A 2-section filter is adequate when the frequency separation between transmitters is at least 7.5 mc. Where the separation is 6.3 mc, a 4-section filter must be used. Each filter section has an insertion loss of about 0.5 db and attenuation characteristics as shown in Fig. 6.

Fig. 7 shows two Lenkurt type *72B* transmitters which are multiplexed upon one common transmitting antenna. The multiplexer panel, shown near the top of the transmitter on the left-hand side, has a capacity of three transmitters. Four-section filters are used in this case because the frequency separation between transmitters is only 6.3 mc. For this particular application, the traffic load is such that two circuits will provide the necessary capacity at this time; however, at the present rate of growth, it is estimated that within a few years one additional circuit will be required. The frequency for this additional circuit has been allocated and the multiplexer filters tuned and factory-tested. At the time of installation of the third transmitter, a cable patched between the multiplexer and transmitter power output panel will be the only requirement for connection of the new transmitter to the existing antenna system. Although not shown, a similar arrangement is provided for the receiving system. This type *72B* radio circuit has an ultimate capacity of 216 toll-quality telephone channels and 3 voice-frequency order wire channels, plus a large number of alarm and pilot tone channels.

Diplexing. To allow simultaneous operation on a single antenna of a transmitter and a receiver (diplexing), the recommended minimum frequency separation between transmitter and receiver is 12 mc. The primary purpose of the transmitter filter is to prevent the transmitter from loading the antenna at the receiving frequency. A 2-section filter having an attenuation of 25 db at the receiving frequency and an insertion loss of 0.5 db provides the necessary isolation.

The receiving filter must, in addition to preventing receiver loading of the antenna at the transmitting frequency, provide sufficient isolation between the transmitter and receiver to prevent the creation of objectionable modulation products in the front end of the receiver. Such modulation products are primarily difference frequencies between high-order harmonics of the local oscillator mixer injection frequency and of the transmitter frequency. For example, when the transmitting frequency is lower than that of the receiver and the difference between them is equal to one half the receiver intermediate frequency, a product is created in the first mixer stage between twice the transmitting frequency and twice the injection frequency. This product is equal to the intermediate frequency. There are numerous other discrete frequency combinations which will result in objectionable interference unless sufficient isolation is provided.

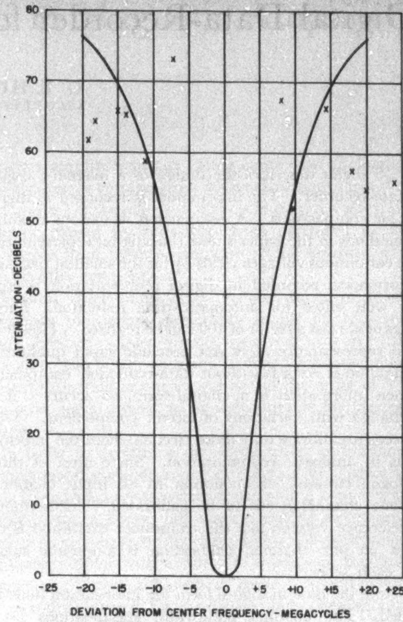


Fig. 8. Attenuation of a 4-section filter. The crosses show the required attenuation when diplexing

The interfering effect of the frequencies within the operating range of the receiver, and the isolation required between the transmitter and receiver, determine the attenuation required to the transmitter. This requirement is shown in Fig. 8 on the same co-ordinates as a curve showing the attenuation provided by the 4-section receive filter.

Multidiplexing. A frequently used combination of equipment, two transmitters and two receivers, may be operated on a single antenna through use of a multidiplexer; a combination of a multiplexer and a diplexer. The necessary filter characteristics for this arrangement may be obtained through analysis of the requirements for both the multiplexer and diplexer. Four-section filters are used on the receiving lines and 2-section filters on the transmitting lines, if the minimum frequency separation between a transmitter and a receiver is 12 mc, between receivers is 6.3 mc, and between transmitters is 7.5 mc. The spacing between transmitters could be reduced to 6.3 mc through use of 4-section filters on the transmitting line.

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Digital Data-Recorder for Dense Storage of Voltages

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THIS digest describes the design of a magnetic digital data-recorder. The information is recorded in digital form for compactness. A comparison of various modulation methods in the paper shows that digital representation of the continuous voltages yields by far the smallest package.

Information recorded in digital representation is especially well suited for automatic data reduction. Labor savings of at least a factor of 100 can be realized. However, digital representation does not preclude rapid qualitative examination of records without data-reduction equipment.

When information is in digital form, its accuracy does not change with variations of circuit components. Thus one needs to calibrate only those circuits where the information is in analogue representation. Since most of those "analogue circuits" are common to all input channels, only one channel needs to be calibrated. Furthermore, if a reference voltage like the transducer excitation is recorded on one channel, calibration is automatic many times each second.

To store the data in digital form the information must be sampled. The channel bandwidth specifications listed below are in terms of samples per second. With approximately three samples per cycle of the highest information frequency in each channel, all information can be recovered with the accuracy specified below.

Minimum design-goal specifications of a recorder are

Precision of the data	±0.5 per cent
Bandwidth of the precision channels	
1 channel	5,000 samples/second
8 channels (each)	600 samples/second
Minimum operating time	8 minutes
Maximum volume	500 cubic inches

In addition, amplitude-modulated channels with a bandwidth of 10,000 cycles per second are available. At reduced operating time, the bandwidth of the amplitude-modulated channels can be increased to 80,000 cycles per second.

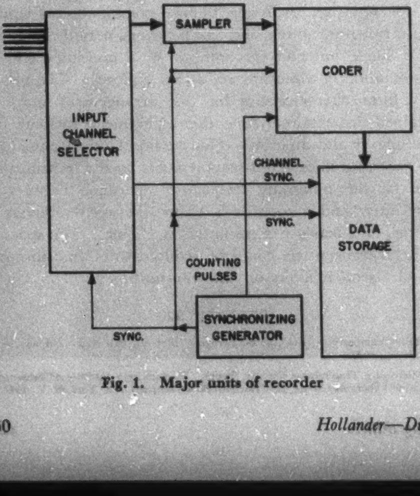

Fig. 1. Major units of recorder

With an external adjustment, the nine precision channels can be combined into a single channel with a sampling rate of approximately 10,000 samples per second. Other combinations of the eight low-frequency channels can yield four channels with a sampling rate of 1,200 samples per second; or two channels, of 2,400 samples per second.

With the flexible building-block design, digital data-recorders can be packaged to other specifications. Typical alternatives are described in the paper.

Essentially, the digital data-recorder consists of a 28-track magnetic-tape recorder and auxiliary circuits that multiplex the input channels and convert the voltages into binary code (Fig. 1). While the auxiliary circuits occupy as much space as the data storage unit, the efficiency of digital representation yields an over-all volume reduction for operating times of more than 5 minutes.

The major components of the recorder are shown in Fig. 1. The input-channel selector connects one of the input channels to the sampler, which samples the selected voltage and holds it during the entire coding interval. The coder converts the sampled voltage to digital form, which is then stored in the data storage unit. The synchronizing generator supplies counting pulses for the coder and coordinates the timing of all operations. A synchronizing pulse from the input-channel selector is also recorded to aid in identifying the data during playback.

The paper has presented the design of a recorder that stores in digital form continuous voltages from various transducers. In digital representation:

1. More information can be stored in limited space.
2. Data can be reduced automatically.
3. Calibration is simplified, because the same critical circuits are shared by all channels.

While the paper describes a specific design, the principle of digital representation can be used advantageously for many instrumentation systems where space is at a premium.

The significance of this design is that for most high-precision wide-band recording applications, digital representation of the data yields the smallest package, even if the coding equipment is included in it.

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Digest of paper **54-318**, "A Digital Data-Recorder for Dense Storage of Continuous Voltages," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE-IAS-IRE-ISA Conference on Telemetering, Chicago, Ill., May 24–26, 1954. Published in AIEE *Communication and Electronics*, vol. 73, pt. 1, July 1954, pp. 253–9.

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Asymmetry Zero-Drift Errors in Magnetic Amplifiers

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MAGNETIC-AMPLIFIER push-pull circuits, as used with position-indicating synchrotransmission systems, are supposed to have no output, if the input voltage is zero as a result of exact coincidence of alignment between the control-transformer rotor and the synchrogenerator rotor.

It is required that fulfillment of this condition be independent of changes in magnitude and frequency of a-c line voltage, changes in ambient temperature, etc.

The conventional way of applying magnetic amplifiers to such synchro systems consists in operating the magnetic-amplifier circuit directly from the same 60-cycle or 400-cycle power source from which the synchro system is operated, connecting the input of the amplifier to the synchro-control transformer, and controlling a 2-phase induction-type reversible motor, geared to the control transformer, with the output of the amplifier.

Since the magnetic amplifier is directly connected with the a-c line feeding the line phase of the motor, any undesired output caused by asymmetry zero-drift errors of the amplifier itself will cause the motor to operate exactly in the same way as the desired signal-proportional output does.

Thus, the 2-phase motor, when operated in this way, is unable to discriminate between error-signal output and zero-drift output of the magnetic amplifier.

It is well known that "asymmetry zero-drift errors" caused by actual deviations from perfect symmetry of the saturable-reactor and dry-disk rectifier components of magnetic-amplifier push-pull circuits may be reduced to certain specified values by using proper testing procedures for grading and matching of these components. However, limitation of such errors to sufficiently small values still represents a difficult problem in design and production of high-performance magnetic servo amplifiers.

Asymmetry zero-drift errors can be eliminated by supplying the magnetic-amplifier push-pull circuit from a magnetic frequency multiplier producing an exact multiple of the frequency of the a-c line feeding directly both the line phase of the 2-phase motor and the synchro generator of the error-detecting system. For example, when employing a 400/1,200-cycle frequency tripler for this purpose, a carrier frequency of 1,200 or 2,400 cycles per second is applied to the output-circuit elements of the magnetic amplifier, while the line phase of the motor and the synchrogenerator then are directly supplied from the 400-cycle power source.

In this case, the 2-phase motor is able to discriminate between amplifier output values caused by application of 400-cycle error voltages from the synchrocontrol transformer and those 1,200-cycle or 2,400-cycle output values, which may be caused by zero-drift errors produced by actual deviations from perfect symmetry of the saturable-reactor and rectifier components.

Various single-phase and 3-phase types of magnetic frequency multipliers, preferably simple 60/180-cycle or 400/1,200-cycle tripler circuits, operating with an efficiency of about 70 to 80 per cent and having a fundamental component distortion of output voltage in the order of 5 to 10 per cent, have proved to be very suitable for use for this purpose.

In order to determine the actual effect of fundamental component distortion, asymmetry zero-drift measurements on a closed-loop servo system containing a conventional 2-phase motor, a 2-stage half-wave magnetic servo amplifier, and a single-phase bridge-type 400/1,200-cycle magnetic frequency tripler with about 6 to 8 per cent fundamental component distortion have been made. Actual magnitude of zero-drift caused by excessively large deviations from symmetry of the magnetic amplifier components has been measured directly in the closed-loop system by observing the angular deflections of the shaft of the motor by means of a little mirror and a light beam, as conventionally used in mirror-type galvanometers.

Actually, with fundamental component distortions in the order of 5 to 10 per cent of conventional types of magnetic frequency multipliers, even very large deviations from symmetry of the push-pull circuit components do not have any effect in this case on the angular position of the motor shaft.

It is to be noted, however, that the application of a higher frequency carrier and operation of the magnetic servo amplifier as a real a-c amplifier does by no means decrease the well-known zero-drift effect of any line-frequency pickup voltages injected into the input circuit of the amplifier.

Such additional error voltages present, which may be caused by undesired capacitive currents or by unintentional coupling effects, should be eliminated by careful electrostatic shielding and grounding of windings and proper wiring design.

Of course, application of a higher frequency carrier for supplying the magnetic servo amplifier also offers other important advantages in so far as the operation of this amplifier becomes more efficient, and that its speed of response (and also the bandwidth of the closed-loop servo system) will be correspondingly increased.

Finally, it may be stressed that magnetic amplifiers and magnetic frequency multipliers have almost unlimited life. Thus it is possible to seal both these components hermetically in a single compact case.

Digest of paper 55-59, "Elimination of Asymmetry Zero-Drift Errors in Magnetic Servo Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1955. Scheduled for publication in AIEE *Communication and Electronics*, 1955.

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INSTITUTE ACTIVITIES

Massachusetts Institute of Technology will be visited during the Summer Meeting

Summer General Meeting Promises Diversified Program, Excellent Vacation

AIEE'S 1955 SUMMER GENERAL Meeting promises a diversified technical program—54 sessions—plus an excellent opportunity for a New England vacation. This year's Summer Meeting will be held at Swampscott, Mass., June 27–July 1, with headquarters at the New Ocean House. Swampscott is 15 miles north of Boston. The AIEE Lynn and Boston Sections, sponsors of the meeting, invite members to make reservations now for accommodations.

Technical Sessions

The 54 technical sessions and symposia are being planned by the Institute's 40 technical committees. In the Power Division, sessions are planned on insulated conductors, system engineering, relays, transmission and distribution, power generation, protective devices, rotating machinery, switchgear, carrier current, and transformers.

In the Communications Division, the following technical committees are planning sessions: Communication Switching Systems, Television and Aural Broadcasting, Radio Communications Systems, Wire Communications Systems, and Telegraph Systems.

Science and Electronics Division committees are sponsoring sessions on: basic sciences, computers, infrared devices, electronic circuitry, magnetic amplifiers, semiconductors, instruments and measurements.

In the Industry and General Applications Divisions, the following sessions are being organized: chemical, electrochemical and electrothermal applications, feedback control systems, textile industry, industrial power systems, metallic rectifiers, and land transportation.

General committees planning Sessions include Committees on Management, Safety, and Code of Principles of Professional Conduct.

Student Activities

Monday, June 27, has been designated as the day for special student activities. Registration at the Student Membership Desk will take place in the morning, followed by attendance at the general session, and informal group meetings of student members. At noon students will be guests of the General Electric Company for a catered luncheon at the Measurements Laboratory. In the afternoon there will be a special technical session for students. There will also be a choice of participating in a scheduled trip or swimming. A dinner will be held in the evening at the Thomson Club, Nahant, Mass., (tickets $1.50), and a barn dance will be held at the New Ocean House.

Ladies' Program

The Ladies' Activities Committee has arranged a coffee hour every morning at 9:00 a.m. On Monday, June 27, there will be a "Get Acquainted Tea;" Tuesday, a tour of Boston and lunch at the Massachusetts Institute of Technology; Wednesday, a tour of the Saugus Iron Works, and Marblehead, Mass., as well as visits to craft exhibits and bazaars. On Thursday, there will be a tour of Salem, Rockport, and the Hammond Castle, with lunch at Castle Hill.

Banquet

A highlight of the meeting will be the banquet on Wednesday evening, June 29.

Reservations

The Hotels Committee chairman, R. E. Franck, urges early reservations. Mail requests for reservations directly to the New Ocean House, Swampscott, Mass., and state that it is for the 1955 AIEE Summer General Meeting. In addition to the New Ocean House, hotel space has been reserved in the nearby towns of Lynn, Marblehead, and Salem, as well as some in Boston. Hotel rates at the New Ocean House range from $11.00 to $14.00 per day, including meals. For motel accommodations, contact R. E. Franck, General Electric Company, 40 Federal Street, West Lynn, Mass.

Committee Members

M. A. Princi is general chairman of the Summer General Meeting Committee and Nicholas Stadfeld is Technical Program chairman. Assisting Mr. Princi are: C. W. Maloney, vice-chairman; J. R. MacIntyre, secretary; R. G. Slauer, treasurer; J. F. Archibald and E. K. Rohr, advisory; L. F. Cleveland, students; J. A. Cook, financial; J. R. Cornell, Jr., transportation; R. E. Franck, hotels; E. A. Harty, registration; P. H. Houser, sports; S. M. Osthagen, publicity; T. C. Sargent, entertainment-banquet; A. L. O'Banion, entertainment; A. M. Bjontegard, inspection trips; Mrs. M. A. Princi, ladies.

AIEE Appliance Conference to Cover "The Trend to Built-In Appliances"

THE MAJOR THEME of the sixth annual AIEE Appliance Technical Conference will be "The Trend to Built-in Appliances." This year's conference will be held in Cleveland, Ohio, May 23–24, with headquarters at the Hollenden Hotel. Last year about 220 engineers attended the conference, and it is hoped this year's meeting will be as successful.

Of particular interest should be a symposium on Monday, May 23. Helen Kendall, director of appliances and home care, *Good Housekeeping* magazine, plus a panel representing three manufacturers, a design firm, and a utility company will discuss trends in appliance design with emphasis on built-in equipment.

This year two movies will be presented: "The Cornell Kitchen" and "The Magic Link." The first will be presented by Glenn Beyer, director of the Housing Research Center, Cornell University, and the second film is by the courtesy of Consolidated Edison of New York.

The tentative technical program follows.

May 23, Monday

9:00 a.m. Registration

10:00 a.m. Morning Session

Welcome to Cleveland. J. L. Fuller, chairman, AIEE Cleveland Section

Keynote Address. A Look into the Future. (Speaker to be announced)

Kitchen Layout Studies. *Glenn Beyer*, Cornell University

Movie: The Cornell Kitchen

Installation and Service Considerations in Built-in Appliances. *E. H. McNiece*, Detroit Edison.

1:30 p.m. Afternoon Session

The Homemaker's Viewpoint on Built-in Kitchens. *Helen Kendall*, *Good Housekeeping* Magazine

Symposium: Trends in Appliance Design With Emphasis on Built-in Equipment. *Helen Kendall* and panel representing three manufacturers, a design firm, and a utility company

Movie: The Magic Link

May 24, Tuesday

9:30 a.m. Morning Session

The Effect of the Built-in Appliance Trend on Design and Installation. *J. H. Robinson, Jr.*, General Electric Company

Proposed Small Appliance Cooking Center. *K. G. Smith*, Globe American Corporation

Aluminum in Appliances.

General Electric Major Appliance Color. *E. W. Harrison*

1:30 p.m. Afternoon Session

Statistical Methods Applied to Automatic Washer Tests. *C. H. Fuchs*, Westinghouse Electric Corporation

Flash-Type Steam Iron Design. *B. B. Krammes*, The Hoover Company

Surface Emissivity as a Design Factor in Appliances. *A. D. Smith*, Westinghouse Electric Corporation

Future AIEE Meetings

Middle Eastern District Meeting
Deshler-Hilton Hotel, Columbus, Ohio
May 4–6, 1955
(*Closing dates for TP[*] and DP[†]—closed*)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(*Final date for submitting papers—closed*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(*Final date for submitting papers—closed*)

Domestic Appliance Conference
Hotel Hollenden, Cleveland, Ohio
May 23–25, 1955
(*Final date for submitting papers—closed*)

Electronic Components Conference
Ambassador Hotel, Los Angeles, Calif.
May 26–27, 1955
(*Final date for submitting papers—closed*)

AIEE-APS-AIME-CIT Conference on Magnetism and Magnetic Materials
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—closed*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Closing dates for TP and CP[‡]—closed*)

Pacific General Meeting
Butte, Mont.
August 15–19, 1955
(*Closing dates for TP—May 16, CP—June 15*)

Petroleum Technical Conference
Shamrock Hotel, Houston, Tex.
September 12–14, 1955
(*Final date for submitting papers—June 13*)

AIEE-ISA Instrument Conference
Shrine Auditorium, Los Angeles, Calif.
September 12–16, 1955
(*Final date for submitting papers—June 13*)

AIEE-IRE Industrial Electronics Conference
Rackham Memorial Auditorium, Detroit, Mich.
September 28–29, 1955
(*Final date for submitting papers—June 28*)

1955 Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 3–7, 1955
(*Closing dates for TP—June 6, CP—Aug. 3*)

Motor Applications and Problems in Heating and Cooling Conference
St. Louis, Mo.
October 18–20, 1955
(*Final date for submitting papers—July 18*)

[*] TP—Transactions papers
[†] DP—District papers
[‡] CP—Conference papers

A "new look" is coming to Pittsburgh, Pa. Federal, state, city, and business interests have joined in a $1,500,000,000 project to transform the downtown area, to be completed next year. Visitors to the Magnetics Conference will be able to see many of these changes.

Magnetics Conference, June 14–16, To Be Sponsored by the Institute

MAGNETISM and magnetic materials are the subjects to be discussed at the first Magnetics Conference sponsored by AIEE. Other sponsors are the American Institute of Mining and Metallurgical Engineers, the American Physical Society, and the Carnegie Institute of Technology. Both the conference and an exhibit will be held in the William Penn Hotel, Pittsburgh, Pa., June 14–16. The purpose of this meeting is to bring together all those interested in basic and applied work on magnetism.

Technical Sessions

There will be six sessions covering the following subjects: magnetic materials, metallurgy of magnetic materials, mechanism of magnetization, application and manufacturing of soft materials, permanent magnets, measurements and techniques, ferrites, and high-frequency switching and storage of information. Plans are to have presentations of original and review papers varying in length from 5 to 30 minutes, on 2 days or more, and organized trips during one day to companies and institutions in the Pittsburgh area.

It is also planned to have 500- to 1,000-word abstracts of all talks distributed before the meeting. Time for presentation will be allotted on the basis of these abstracts. Publication of the complete proceedings is under consideration.

Dormitories have been made available by Carnegie Institute of Technology and a large lecture room by the Mellon Institute. Arrangements are being made by the Pittsburgh sections of the societies, and working with the other societies is the Magnetics Subcommittee of AIEE's Basic Sciences Committee.

For information write A. C. Beiler, Westinghouse Electric Corporation, 2-F Materials Engineering Department, East Pittsburgh, Pa

AIEE Farm Electrification Conference Enthusiastically Received in Chicago

WHILE ELECTRIC POWER use, in general, will probably double in the next 10 years, the use of electric power on the farm may triple. This was pointed out at AIEE's Farm Electrification Conference held at the Morrison Hotel in Chicago, Ill., March 8–10. The conference was enthusiastically attended by 211 persons from 23 states and Canada. They represented electrical utilities, co-operatives, the U. S. Department of Agriculture, Rural Electrification Administration, electric equipment manufacturers, Underwriters' Laboratory, research organizations, and college agricultural engineering departments.

Emphasis was on the knowledge that farm prices are not expected to increase to any great extent in the future. Therefore, in order to survive, the farmer must lower his costs through more efficient use of electric energy. Latest information about use of electricity on present poultry, dairy, and livestock farms was presented, and past, present, and future aspects of farm electrification were also discussed.

The inspection trip, attended by 67 conferees, was to two modern electrified farms with total connected loads in the size of 40–45 kw. These farms were chosen rather than model farms in the area because they represented actual working farms.

Discussions following each speaker's presentation had more than normal participation on the part of conference members, and the panel on "Serving Heavy Loads for Poultry and Livestock Farms" was outstanding in this regard.

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in Swampscott, Mass., at 10:00 a.m., Monday, June 27, 1955, during the Summer General Meeting.

At this meeting the annual report of the Board of Directors and the reports of the Committee of Tellers on the ballots cast for the election of officers and for the proposed amendments to the AIEE Constitution will be presented. The Lamme Medal will be presented to A. M. deBellis (M '33, F '48).

Such other business, if any, as may properly come before the annual meeting may be considered.

Signed N. S. HIBSHMAN

Secretary

Engineers Joint Council Issues Annual Report of Activities for 1954

THE ANNUAL REPORT for 1954 in which the year's activities are summarized, was recently issued by the Engineers Joint Council (EJC). The report also includes the EJC constitution, bylaws, directory, and a list of the Council's committees for 1955. The organization of EJC and its development was discussed in an article in *Electrical Engineering*, May 1954, (pages 406–11), and a list of the officers and executive committee will be found on page 437 of this issue of *Electrical Engineering*.

Changes in the secretariat took place in 1954. T. A. Marshall, Jr., resigned as secretary as of April 1954, and was succeeded by Brigadier General S. E. Reimel on a part-time basis. E. P. Lange was appointed assistant secretary in May 1954 and became secretary on April 1, 1955. General Reimel become secretary of the EJC Committee on International Relations.

During 1954 the EJC constitution was amended by providing for nonvoting membership of societies having less than 5,000 members but otherwise meeting full membership requirements, and also for affiliation of regional societies and federations of societies meeting certain requirements.

During the year two new activities were started. One was the beginning of work on a "Finders' List" of engineers for the National Scientific Register, supported by a grant from the National Science Foundation. The other was the establishment of an Operating Committee on Nuclear Engineering to provide a means for effective coordination of the separate interests of societies in the field. A Congress on Nuclear Engineering is planned under EJC auspices later this year.

Anyone interested in further details of the EJC report may obtain copies from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

AIEE's Pacific General Meeting Offers Technical Program, Western Entertainment

THE INSTITUTE'S Pacific General Meeting to be held at Butte, Mont., this year promises to be a rare combination—technology and western-style entertainment. The meeting is scheduled for August 15–18 with headquarters at the Hotel Finlen. Trips are planned to electrical installations, a copper mine, the world's largest copper smelter, to Lewis and Clark Cavern, and to ghost gold-mining towns. And, fishing and picnicking are considered "tops" along the many lakes and streams. Golfers, too, will enjoy the Butte Country Club. Those who plan to drive to the meeting can schedule visits to Glacier or Yellowstone Park as part of a combination AIEE meeting and vacation.

COMMITTEE CHAIRMEN for AIEE's Pacific General Meeting are (front row, left to right): Dean E. W. Schilling, R. C. Setterstrom, Mrs. C. A. Champ, W. H. Mott, and W. H. Blankmeyer. (Back row, left to right): N. V. Anderson, R. J. Carlson, D. E. Kampschor, R. J. Labrie, and R. C. Nealey. Absent from picture: Mrs. W. H. Mott and Dales Schekles.

Reservations

All hotel, motel, and dude ranch reservations will be handled by the committee. Dude ranches are about an hour's drive away—close enough to attend technical meetings and still live in western surroundings. R. J. Labrie, chairman of the Hotel Committee, asks the help of all delegates who are sure to attend the meeting by letting him know of their minimum room requirements at the earliest possible date. Because of limited hotel facilities in Butte, early knowledge of registration and reservation requirements will assist the committee in making adequate preparation. Write to R. J. Labrie, Hotel Committee Chairman, 2725 St. Ann Street, Butte, Mont.

Deadlines Set for Aircraft Equipment Conference Papers

A special technical conference on aircraft electrical applications will be held at the Biltmore Hotel, Los Angeles, Calif., October 11–13, 1955. F. L. Lyons of Northrop Aircraft, Inc., Hawthorne, Calif., has been appointed chairman of the conference, and T. B. Holliday, 248 Arlington Avenue, Elmhurst, Ill., is in charge of the technical program. The deadline for *Transactions* papers is July 11, to be received at AIEE headquarters, 33 W. 39th Street, New York, N. Y. It is planned that all papers will be bound together and be made available at the conference. To accomplish this, conference papers must also be received in reproducible form no later than August 11.

Former Baton Rouge Subsection Is Now Chartered AIEE Section

AIEE's Board of Directors has authorized formation of the Baton Rouge, La., Section. This brings the total number of Sections to 107. The new Section was formerly a Subsection of the New Orleans Section. E. H. Coxe, power supervisor, Ethyl Corporation, Baton Rouge, is chairman, and J. W. Elder, also of Ethyl, is secretary.

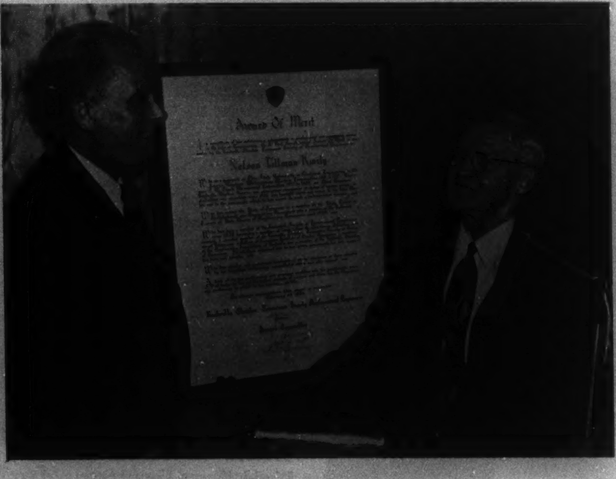
Travel Plans Considered for World Power Conference

Engineers Joint Council (EJC) has announced that a travel agency will be selected soon in connection with the Fifth World Power Conference to be held in Vienna, Austria, June 17–23, 1956. Those planning to travel by ship are urged to send in their requests early.

EJC headquarters are at 29 West 39th Street, New York 18, N. Y.

AIEE Middle Eastern District Meeting Set for May 4-6

THE MIDDLE EASTERN DISTRICT MEETING COMMITTEE (left) has arranged a varied technical and social program to take place at the Deshler-Hilton Hotel in Columbus, Ohio, May 4–6. (See April *Electrical Engineering* for program and meeting details.) Seated left to right: L. M. Moore, administration; P. L. Gilmore, Jr., entertainment; E. E. Dreese, technical program; E. K. McCoy, general chairman; J. W. Cade, arrangements. Standing left to right: N. A. Smith, student meeting; E. O. Wolden, publicity; G. R. Tamblin, co-ordinating secretary; C. K. Bishop, special meetings. Also on the committee, but not in the picture, are: G. M. L. Sommerman, honorary general chairman; R. C. McMaster, advisory; N. J. Greene, finance; and D. E. Stafford, treasurer. Picture at right shows the control and instrument panel of the electric transmission loss penalty factor computer installed in the American Gas and Electric System's production co-ordination office. American Gas and Electric is on the list of tours for those attending the meeting.



AIEE Member Wins Award

AWARD OF MERIT was given to AIEE member Nelson Tillman Kinzly (right) at a dinner meeting held by 11 Nashville, Tenn., sections of engineering societies, February 23. The first R. Paul Farrell Award of Merit was a surprise feature of the meeting and was presented by the Nashville chapter of the Tennessee Society of Professional Engineers (TSPE). Mr. Kinzly, distribution superintendent, Nashville Electric Service, received the award "in recognition of his outstanding achievements in professional and community service in the field of engineering." W. H. Mann, chairman of TSPE's Nashville chapter, made the presentation.

Central Indiana Section Sponsors Annual Student Paper Competition

The Annual Prize Paper Competition between students of Rose Polytechnic Institute and Purdue University was held at Purdue, March 10. The contest was sponsored by AIEE's Central Indiana Section. Wade Morris of Purdue won first-place honors for his paper, "Silicones." Kenneth Gross of Rose Polytechnic, James Meditch of Purdue, and B. L. Kellam, Rose Polytechnic, were runners-up, in that order.

Student members were guests of the Section at a dinner preceding the meeting. C. M. Summers, AIEE Vice-President, Great Lakes District, was speaker.

New officers of the Section (1955–56) are: E. E. Sterner, chairman; R. A. Road, first vice-chairman; J. R. Wark, second vice-chairman; T. W. Metz, secretary-treasurer. Executive committee members are: H. W. Hale, R. D. Strum, and R. H. Jordan.

ECPD Publishes Papers on Training in Modern Industry

Four papers on orientation and training in modern industry are available in a publication of the proceedings of the 22d Annual Meeting of the Engineers' Council for Professional Development (ECPD). These papers were presented by representatives of four industrial firms that have participated in the pilot study of the ECPD program known as, "The First Five Years of Professional Development."

Also included in the publication is an introduction to the question of professional industrial training by AIEE President A. C. Monteith.

There is a copy of the brochure describing the program for young graduate engineers during the "First Five Years" and a copy of the brochure reporting on "The Community Project in Professional Development" which has been studied recently in Cincinnati, Ohio. Copies of this publication are available by addressing the ECPD Committee on Professional Training, 322 Baldwin Hall, Cincinnati 21, Ohio.

Engineers, Architects Conference Set for May 6 at Ohio State

The Second Annual Conference for Engineers and Architects will be held May 6, 1955, at the Ohio State University, Columbus. John C. Sharp, president of the Hotpoint Company, and General Curtis E. LeMay will be main speakers at the general session and noon banquet, respectively. University engineering departments sponsoring sessions include: electrical, aeronautical, agricultural, ceramic, chemical, civil, drawing, mechanics, industrial, mechanical, metallurgical, mining and petroleum, and welding.

Gordon B. Carson, director of the conference, urges advance registration. Hotel reservations may be made directly with the Deshler-Hilton Hotel, Neil House, or Fort Hayes Hotel. The conference committee will make reservations if asked to do so with advanced registration. Also, motels are located on *U. S. 40*, on East Main, and West Broad Streets. If such reservations are desired, these may be secured directly with the motel upon arrival.

Dr. Thorndike Saville Re-elected President of EJC

Dr. Thorndike Saville, dean of the College of Engineering at New York University, has been re-elected president of the Engineers Joint Council (EJC) for 1955. Dr. Saville is a past president of the American Society for Engineering Education and past director of the American Society of Civil Engineers. Elected vice-president was Edgar J. Kates, consulting engineer of New York City. Mr. Kates, a Fellow of The American Society of Mechanical Engineers, was a director-at-large of that society from 1945 to 1949, and and since 1949 he has been assistant treasurer.

The new executive committee consists of Dr. Saville, Mr. Kates, and the following engineering society representatives: C. S. Proctor, American Society of Civil Engineers; L. F. Reinartz, American Institute of Mining and Metallurgical Engineers; W. W. Brush, American Water Works Association; B. W. Morton, AIEE; L. R. Sanford, Society of Naval Architects and Marine Engineers; and F. J. Van Antwerpen, American Institute of Chemical Engineers.

Michigan Section Proves Active

COMMUNICATIONS TECHNICAL GROUP meeting of the AIEE Michigan Section was held at The Detroit Edison Company, January 26. The panel above discussed applications of telephone circuits, microwave, carrier current, and mobile radio in the operation of a utility system. Seated left to right: V. R. Owens, T. P. Rykals, R. A. Dage. Standing: F. L. Burge and F. L. Taylor. Below is picture taken at a Section meeting.

THE TENNESSEE VALLEY AUTHORITY (TVA) power program was the topic of Brigadier General H. D. Vogel (second from left) at the Michigan Section's March 15 meeting. General Vogel is chairman of the board of directors of the TVA. H. R. Armstrong, secretary-treasurer of the Section, is to the left of General Vogel. To the general's right are Walker Cisler, president of The Detroit Edison Company, and Professor J. J. Carey, Section chairman.

Electric Heating Conference To Be Held May 10–11 in Chicago

AIEE's Electric Heating Conference will be held May 10 and 11 in Chicago, Ill., with headquarters at the La Salle Hotel. Eighteen papers on subjects to interest everyone in the industrial heating field will be featured at the meeting.

Dr. Hubert N. Alyea, professor of chemistry, Princeton University, will present the banquet address on May 10. His subject will be "Atomic Energy—Weapon for Peace."

The welcoming address will be given by Harold R. Heckendorn, assistant superintendent, manufacturing engineering, Western Electric Company, Chicago, Ill. Harold Bunte of Commonwealth Edison Company, and chairman of the AIEE Committee on Electric Heating, will preside at the opening session, May 10. For the tentative program see page 345 of the April *Electrical Engineering*.

Union College Branch Is Host for Joint AIEE Meeting

It has been the annual custom of the Schenectady Section of AIEE to hold a joint meeting with the Student Branches of Union College and Rensselaer Polytechnic Institute (RPI). This year, on February 16, Union College was host for the meeting.

Francis Wise, chairman of the Union College Branch, presided and opened the meeting with the introduction of the department head and professors of electrical engineering at Union, the officers of the Union College Branch, and the guests from RPI. Highlight of the meeting was a talk by E. W. Colehower, design engineer for the Glenn L. Martin Aircraft Company, the title of his presentation being "Aircraft Electrical Systems." Mr. Colehower's talk, illustrated with slides, was centered around aircraft generation, distribution, and utilization systems, as well as recent advances, problems, and future developments along these lines.

EJC Elects New Constituent Society and First Associate

Engineers Joint Council (EJC) has announced at its headquarters in New York, N. Y., the election of The American Society of Refrigerating Engineers as a constituent society. The election of the American Institute of Industrial Engineers as an associate, the first organization to become an EJC associate, has also been announced. EJC now has nine constituent societies with a total membership of more than 196,000.

The Council has been taking steps toward increasing the unity of the engineering profession. A total membership of at least 5,000 is required of a national organization to qualify for constituent membership. The American Society of Refrigerating Engineers, which has headquarters in New York, N. Y., has more than 6,200 members. A recent constitutional amendment permits EJC to admit as associates national organizations of

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until *May 30*. Duplicate double-spaced typewritten copies of each discussion should be sent to Edward C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y., on or before *May 30*.

55-71 **Voltage Gain of a Resonant Dielectric Amplifier.** *Sack* and *Penney*.
55-143 **Directional Relays Provide Differential-Type Protection on Large Industrial Plant Power System.** *Gilbert* and *Bell*.
55-175 **A Polar Relay Using Momentum Transfer.** *Garbarino* and *Bisshopp*.
55-242 **Temperature Errors in a Dragmagnet Eddy-Current Disk Type of Tachometer Indicator.** *Akeley* and *Fraizer*.
55-245 **Manufacturer's Research in Relation to Electrical Utilities.** *Parker* and *Baird*.

Preprints may be purchased at 30¢ each to members, 60¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to:

AIEE Order Department
33 West 39th Street, New York 18, N. Y.

Memphis Members See Wave Demonstrator

MECHANICAL WAVE DEMONSTRATOR was seen by members at the February 15 meeting of AIEE's Memphis Section. Miles Maxwell (second from left), used the demonstrator to support his talk, "Mechanical Demonstration of Traveling Waves." He is electric utility engineer for the Westinghouse Electric Corporation in East Pittsburgh, Pa. Various basic voltage wave reactions encountered in power distribution systems were illustrated by the machine. These voltage wave reactions, caused by lightning and switching surges, he said, were responsible for more costly damage to electric equipment than any other factor. Others shown are John Thrithart (left), Section chairman, and Claude Young (right), secretary.

less than 5,000 members. The American Institute of Industrial Engineers has some 3,000 members. Its headquarters are in Columbus, Ohio.

Red River Valley Division Establishes Two Scholarships

The Red River Valley Division of the AIEE Minnesota Section has established two scholarships in memory of Max R. Hughes, AIEE member and a prominent engineer in North Dakota. (Obituary of Mr. Hughes will appear in June *Electrical Engineering*.)

These scholarships are known as the Max R. Hughes Memorial Scholarships to be presented to the outstanding seniors in electrical engineering at the North Dakota State College, Fargo, and the University of North Dakota, Grand Forks. They have a value of $75.00 each. Recipients for next year are Arthur G. Link at the State College and John M. Risan at the University.

Edward Hodges Robie Retires As Secretary of the AIME

Edward Hodges Robie, secretary of the American Institute of Mining and Metallurgical Engineers (AIME) since 1949, has retired from the secretaryship to become secretary emeritus. He will also serve as secretary pro tem of the Mining Branch of the institute. Ernest Kirkendall has been officially appointed to succeed Mr. Robie.

Prior to becoming secretary of the AIME, he was assistant secretary and editor of *Mining Engineering*. He has also worked with the Canadian Copper Company, International Nickel Company, and Harrison Safety Boiler Works.

Mr. Robie was born in Whitney Point, N. Y., November 30, 1886. He graduated from Western High School, Washington, D. C., in 1906, attended Cornell University from 1907–08, and obtained his bachelor's degree in chemical engineering from the University of Michigan in 1911.

AIEE and IES Sections Cosponsor Meeting

MORE THAN 300 ATTENDED a recent program sponsored by AIEE's Los Angeles Section and the Illuminating Engineering Society's Southern California Section. At a dinner meeting prior to the program, 160 persons were present (see above). Chief speaker at the dinner meeting was D. P. Caverly who spoke on "Six Key Lighting Jobs." He described lighting installations pioneering distinct stages in lighting trends.

New Hampshire Section Meets

VICE-PRESIDENT G. J. Crowdes, Perry Ware, guest speaker, Section Chairman R. W. Hunt, and Program Chairman S. A. Clark (left to right), were photographed during the January 5 meeting of the New Hampshire Section. Mr. Ware, head of the electrical laboratory for Simplex Wire and Cable Company, spoke on "Some Properties of New Insulations." Some of the problems involved in the use of synthetics and plastics were discussed as a phase of the subject.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Air Transportation (*W. L. Berry, Chairman; L. R. Larson, Vice-Chairman; Peter Duyan, Jr., Secretary*). At present five subcommittees are writing Standard Test Codes and Guide Reports for use in the aircraft industry. The Aircraft Industries Association has officially endorsed the following AIEE Standards: AIEE *700*—Aircraft D-C Voltage Ratings; AIEE *800*—Test Code for D-C Aircraft Machines; AIEE *801*—Test Code for Aircraft Circuit Interrupting Devices; AIEE *750*—Aircraft Electrical Systems Guide; and the proposed Test Code for D-C Carbon Pile Regulators, which is now published on a 1-year trial basis.

Also, C. G. Martin has been appointed chairman of the Subcommittee on Rating of Airborne Electrical Apparatus.

Committee on Marine Transportation (*W. E. Jacobson, Chairman; J. E. Jones, Vice-Chairman; W. N. Zippler, Secretary*). The committee held a meeting on October 5, 1954, which was attended by G. W. Watson, chief engineer, Lloyd's Register of Shipping, and A. R. Gatewood, chief engineering surveyor, American Bureau of Shipping. Mr. Watson is the liaison representative to the Institution of Electrical Engineers, London, England.

Principal business at the meeting was discussion of differences in British and American marine practice for the promotion of harmony and, if practicable, eventual standardization. No specific action was taken, but it is believed considerable progress was made. Another committee meeting for routine procedure will be held this spring.

The 1954 edition of Standard No. *45*, Recommended Practice for Electrical Installation on Shipboard, has been printed and is now available. This new edition incorporates all the additions and revisions approved by the Committee on Marine Transportation to the end of 1954.

Communication Division

Committee on Telegraph Systems (*E. F. Watson, Chairman; F. H. Cusack, Vice-Chairman; R. B. Shanck, Secretary*). A meeting of this committee was held February 17 in connection with the AIEE Winter General Meeting in New York, N. Y. Plans for future activities were discussed and subjects for technical papers for the coming year were considered.

Consideration was also given to the subcommittee undertaking work to standardize testing procedures, including criteria and types of data needed to evaluate transmission characteristics of telegraphic sending and receiving devices. Main points to be covered would be the quality or accuracy of signals sent from a start-stop sending device, and the tolerances of a start-stop receiving device for recording distorted signals correctly.

Power Division

Committee on Substations (*I. S. Mendenhall, Chairman; W. S. Scheering, Vice-Chairman; J. A. Smith, Secretary*). The committee is starting a new project on fire protection and fire proofing of substations. This project should be of great benefit to utility engineers and others concerned with fire protection.

The committee also plans to conduct a meeting for the discussion on the subject, "Future Trends in Substations." It will be held in Chicago, Ill., probably next fall.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, February 3, 1955

Kenneth R. Brown (AM '30, M '41), owner Brown Engineering Company, Des Moines, Iowa, has been transferred to the grade of Fellow in the AIEE "for contributions to the development and technical integration of electric utilities and to protection of transformers on rural systems." Mr. Brown was born in Rock Falls, Ill., February 27, 1904, and received his education at the University of Illinois. After experience with the Illinois Northern Utilities Company, Dixon, as junior engineer, and with Spooner and Merrill, consulting engineers, Chicago, Ill., he was associated with the Rockford Electric Company. This is now the Central Illinois Electric and Gas Company. He became superintendent of distribution and head of the engineering department, in which position he was responsible for design and supervision of all utility construction. He opened an office for private practice in Rockford, Ill., in 1932. He designed and supervised construction on a wide variety of engineering works for clients. He became chief engineer of the Iowa Farm Bureau Federation, Des Moines, in 1936. He initiated and supervised the engineering activities of the Federation mainly along lines of drainage, flood protection, conservation, etc. During this period he was primarily engaged in rural electrification. He has also made major contributions leading to the Iowa Grid, a state-wide system of transmission lines and power stations now under development in Iowa. He is a registered professional engineer by examination in Iowa, and by reciprocity in Illinois, Nebraska, South Dakota, and Oregon. He is a member of the American Concrete Institute, American Society of Agricultural Engineers, American Society for Testing Materials, and the Iowa Engineering Society. His $3^1/_2$ years' war service included a year in the European Theatre successively as battalion executive, battalion commander, and group commander. He has also received the Bronze Star Medal and was recently retired as a lieutenant colonel of the Organized Reserve Corps.

K. R. Brown

Charles F. Savage (AM '35, M '43), consultant, professional relations, General Electric Company, New York, N. Y., has been transferred to the grade of Fellow in AIEE "for his contributions to the design and development of electrical instrumentation." Mr. Savage was born in Maywood, Ill., February 24, 1906, and obtained his bachelor of science degree in electrical engineering in 1928 from Oregon State College. After graduation he joined General Electric's test program in Schenectady, N. Y. During 1931–33 he designed watt-hour meters, high-voltage insulations, ampere hour meters, and also did portable test standards. He entered the meter and instrument department in 1933 as materials and process engineer. There he was responsible for recommendation and application of finishes, insulations, metallurgy, to watt-hour meters, instruments, time switches, etc. Development, as well as application, was involved. He later supervised the chemical and metallurgical laboratories. From 1939–40 Mr. Savage was division engineer, time switches, in the meter and instrument department. He was responsible for development, design, and placement in production of entire lines of switches. In July of 1940 he became division engineer, aircraft instruments, in the same department. There he was responsible for development, design, and production engineering for entire lines of aircraft instruments. These included engine, flight, and navigation instruments. Electric indicating gyros were a valuable contribution. This was a multimillion dollar operation with a large number of engineers and drafts directly under supervision. In addition to his duties as division engineer, aircraft instruments, he became technical assistant to the engineering manager. This involved responsibilities in areas of transition to peace-time products and increased work in the field of administration and personnel. From 1947–53 he was assistant to the engineering manager, meter and instrument department; from 1953–54, manager of engineering administrative service; and from 1954 to the present, consultant, professional relations, Engineering Services Division, engineering personnel department, General Electric Company. He is author of a number of technical papers and his other memberships include the Institute of Aeronautical Sciences, Tau Beta Pi, Eta Kappa Nu, and the National Society of Professional Engineers. He has worked on AIEE's Instruments and Measurements Committee (1947, 1949–55).

C. F. Savage

AIEE PERSONALITIES.....

A. M. deBellis to Be Awarded Lamme Medal for 1954

Aldo M. deBellis (M '33, F '48), assistant electrical engineer, Consolidated Edison Company of New York, Inc., New York, N. Y., has been awarded the AIEE Lamme Medal for 1954 "for his contributions to the design and development of power station equipment, especially air-insulated phase-isolated metal-clad high-voltage bus structures and disconnecting switches." Mr. deBellis was born in Genoa, Italy, on January 16, 1891, and was educated at the Perugia Institute, the University of Rome, and at the Brooklyn Polytechnic Institute where from 1913 to 1917 he attended the evening school in electrical engineering. In 1913, shortly after coming to the United States, he began work as a draftsman with the then New York Edison Company and in 1916 transferred to the Interborough Rapid Transit Company of the City of New York as assistant engineer. When the United States entered World War I, Mr. deBellis enlisted in the U. S. Navy and saw duty in foreign waters from early 1918 until late 1919, at which time he became associated with Stone and Webster Engineering Corporation, Boston, Mass. In 1920 he returned to the New York Edison Company and when the metropolitan companies were combined into Consolidated Edison Company in 1937 he became assistant inside plant engineer and later, inside plant engineer. He was appointed assistant electrical engineer of the company in 1952. For the last 35 years Mr. deBellis has been closely associated with the electrical design of generating stations and substations to which he has contributed many basic improvements. More recently he has contributed to the development of higher distribution voltages for New York City. He holds patents on electric equipment and has been the author and coauthor of many technical papers which have been presented before the AIEE and the Edison Electric Institute (EEI). Mr. deBellis is one of the authors of the "Standard Handbook for Electrical Engineers" and is a licensed professional engineer in the State of New York. He has served the AIEE as a member of the Automatic Stations Committee (1937–43); the Electrical Machinery Committee (1943–46); Subcommittee on Insulation Resistance (Chairman, 1945–46); and the American Standards Association Sectional Committee on Preferred Voltages, 100 Volts and Under (1947–55). He has also served on the EEI Electrical Equipment Committee (1946–55, Chairman, 1952–54); the Association of Edison Illuminating Companies Committee on Electric Switching and Switchgear (1946–1954); and two International Electrotechnical Commission Committees on Standard Voltages, Currents and Frequencies (1951–55).

A. M. deBellis

C. M. Lathrop (AM '43), assistant division head, engineering department, Standard Oil Development Company, Linden, N. J., has been appointed as a supervising engineer in the Design Division. This is one of many changes announced by the Standard Oil Development Company resulting from changes in the organization of the Esso engineering department. This department has been discontinued and its responsibilities assumed by three divisions. Mr. Byrne, a native of Massachusetts, received both his bachelor's and master's degrees at Massachusetts Institute of Technology, and taught chemical engineering at the University of Notre Dame. After several years with the American Gas and Electric Company, he joined the present Esso Standard Oil Company in 1927 at Baton Rouge, La. He served as chief engineer of the Hydro Engineering and Chemical Company for over 2 years after which he joined the Development Company as a supervisor. He then became a member of Lago Oil and Transport Company, Ltd., where he served as assistant general superintendent of the Aruba refinery. Returning to Standard Oil Development Company in 1937, he was appointed assistant chief process engineer. He was later appointed assistant chief engineer and associate chief engineer. He spent some time in Germany in the early 1930's on an assignment concerning the hydrogenation process. During World War II, he was assistant director of refining with the Petroleum Administration for War in Washington, D. C. He is a member of the American Chemical Society, the American Petroleum Institute, and the American Society for Engineering Education. He is on the AIEE Industrial Power Systems Committee (1947, 1949–55).

D. B. Sinclair (M '45, F '51), chief engineer, General Radio Company, Cambridge, Mass., has been named vice-president for engineering, General Radio Company. Dr. Sinclair joined the company in 1936, after receiving his doctor of science degree from Massachusetts Institute of Technology. He has served the company as engineer, assistant chief engineer, and since 1949, as chief engineer. During World War II, he was associated with the National Defense Research Committee program, working on radar countermeasures and guided missiles. For his work overseas on the former project, he received the President's Certificate of Merit. He is a member of the Institute of Radio Engineers (IRE), the American Association for the Advancement of Science, and of Sigma Xi, honorary scientific fraternity. He has served on the following AIEE Committees: Instruments and Measurements (1948–50); Joint AIEE-IRE Co-ordination Committee (1953–55).

A. R. Teasdale, Jr. (AM '43, M '50), specialist in servomechanisms and automatic controls and a faculty member of Southern Methodist University, Dallas, Tex., has joined Temco Aircraft Corporation's engineering department as chief of electronic design. In his new position, he supervises design and installation of electronic systems, reporting to the technical director of systems design. Teasdale was graduated from high school in Austin, Tex. He received a bachelor of science degree in electrical engineering from the University of Texas in 1942 and joined the General Electric Company, Schenectady, N. Y., as a test engineer. Later that year he qualified for General Electric's advanced engineering program. He was graduated from the advanced course in 1946, and supervised portions of the same program until 1947. He joined the University of Texas Engineering Department faculty late in 1947, first as an assistant professor, then as associate professor of electrical engineering. In 1948 he was assigned as a research engineer on the staff of the university's defense research laboratory. Teasdale received his master's degree in electrical engineering in 1950 at the University of Texas. He continued research work and teaching at the university until 1951 when he joined Convair Corporation's Fort Worth Division as a design specialist in automatic controls. Early in 1954 he was promoted to aerophysics group engineer, the position he held when he left to joint Temco. Since 1951, when he moved to the Dallas–Fort Worth area, Teasdale has been a graduate lecturer in electrical engineering at Southern Methodist University. He has written a number of technical papers, most of which deal with classified subjects. He also holds memberships in Tau Beta Pi, honorary society of engineers; Eta Kappa Nu, electrical engineers' honorary society; and Rho Epsilon Delta, a society composed of honor graduates of General Electric's advanced engineering program. He is also a member of the Institute of Radio Engineers and the Institute of Aeronautical Sciences. Mr. Teasdale's AIEE committee work is with the Feedback Control Systems Committee (1952–55).

R. A. Ramey, Jr. (M '51), manager of the magnetic development section of the materials engineering department of the Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed visiting Webster professor of electrical engineering at the Massachusetts Institute of Technology (MIT), for the second semester of the current academic year. The Webster chair of electrical engineering at MIT was established in 1952 under a grant of $400,000 from the Edwin Sibley Webster Foundation in memory of the late Mr. Webster, one of the institute's most distinguished alumni. During his stay at MIT, Dr. Ramey will participate in the development of teaching and research in the new area of solid state nonlinear devices and their applications to power modulators. Dr. Ramey's appointment became effective February 1. Prior to his appointment with Westinghouse in 1952, Dr. Ramey served as head of the electromagnetic components section of the Naval Research Laboratory. While on this assignment he created a new theory of magnetic amplifiers and invented eight new circuits. He also published a number of basic papers, one of which received the best paper award of the Basic Sciences Committee of AIEE in 1951. In addition, Dr. Ramey is the inventor of the Navy's new underwater log which measures submarine speed to a high degree of accuracy. Born in Wayne, W. Va., Dr. Ramey was educated at Wayne County High School and the University of Cincinnati where he received the degrees of electrical engineer in 1943, master of science in 1945, and doctor of science in 1948. From 1943–1949 he served as research supervisor in the graduate department of applied science at the University of Cincinnati. A member of the Institute of Radio Engineers and Sigma Xi, Dr. Ramey has been active as a consultant and has been a frequent speaker at engineering society meetings.

F. W. Lehan (AM'45), chief, telecommunications section, jet propulsion laboratory, California Institute of Technology, Pasadena, has joined The Ramo-Wooldridge Corporation, Los Angeles, Calif., electronics research and development firm, as electronics research engineer in the Guided Missile Division. For the past 10 years Mr. Lehan has been associated with the jet propulsion laboratory, California Institute of Technology. He received his B.S. at California Institute of Technology in 1944, in electrical engineering. His professional affiliations include the Institute of Radio Engineers (IRE). His writings include articles in *The Journal of Applied Physics* and *IRE Transcript*.

L. B. Bonnett (AM '18, M '25, F '40, Member for Life), vice-president of Consolidated Edison Company of New York, Inc., has retired. He has been with the company 31 years. At the time of his retirement, Mr. Bonnett was in charge of design engineering which covers activities in the electrical and mechanical engineering fields. Over the years, planning, engineering, inventory, purchasing, and stores operations have been directed by Mr. Bonnett. He joined the Brooklyn Edison Company, later merged into Consolidated Edison, as inside plant engineer in 1923. During his first 3 years with Brooklyn Edison, he specialized in design work. In 1926 he took over purchasing and allied functions as purchasing agent of the company. In 1938 he transferred to Consolidated Edison as assistant engineer of design and planning. He was named engineer of design and planning in 1939; and in 1940 became a vice-president of Consolidated Edison in charge of engineering, inventory, purchasing, and stores. As engineer of design and planning and as vice-president of Consolidated Edison, Mr. Bonnett has had a major responsibility since 1938 in planning, design, and engineering connected with Consolidated Edison's postwar expansion program in which system electric stations have been modernized or enlarged and the new Astoria station has been built. Mr. Bonnett was born in Geneva, N. Y. He was graduated from Syracuse University in 1910 with a degree in electrical engineering. Before he joined Brooklyn Edison he worked for General Electric Company in testing and engineering at Schenectady and as a sales engineer in New York. Throughout his utility career he has contributed to the work of many industry and government groups. He is president of the Engineers Club of New York and a director of the American Gas Association and the Regional Plan Association of New York. He is also a member of the New York State Society of Professional Engineers and The American Society of Mechanical Engineers.

E. D. Pettler (AFFIL. '52), electrical engineer, U. S. Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif., has been named resident field engineer in charge of the newly formed Seattle district office of CEC Instruments, Inc., sales and service subsidiary of Consolidated Engineering Corporation, Pasadena, Calif. The new sales and service unit is located in Seattle, Wash. It will serve Consolidated instrument users in the states of Washington, Oregon, Idaho, Wyoming, and Montana, and in the Canadian provinces of British Columbia, Alberta, and Saskatchewan. The unit will operate under the jurisdiction of CEC Instruments, Inc.'s western regional office in Pasadena, Calif. Mr. Pettler, an electrical engineering graduate of Herald Engineering College, San Francisco, Calif., joined CEC Instruments, Inc., in August 1953, as a field engineer in the company's western regional headquarters. During World War II, he was a Pan-American Airways copilot and subsequently served as a radar and electronics instructor at the U. S. Navy Electronics School, Corpus Christi, Tex. From 1948 until 1950, he was electrical engineer for the City of Ventura, Calif.

N. L. Danforth (AM '41), sales representative, Allis-Chalmers Manufacturing Company, Philadelphia, Pa., is now manager of the Toledo, Ohio, district of Allis-Chalmers General Machinery Division. Danforth succeeds **W. W. Moore,** who died October 20th. A representative in Allis-Chalmers Philadelphia district office since 1947, Danforth came to the company in 1940 after receiving his electrical engineering degree from the University of Maine. He served in the U. S. Army Air Force from November 1942 to May 1946.

S. G. Hibben (AM '34, M '45), director of applied lighting for the Lamp Division of the Westinghouse Electric Corporation, and a past president of the Illuminating Engineering Society, has retired from Westinghouse after nearly 40 years of service to the lamp and lighting industry. Dr. Hibben was born in Hillsboro, Ohio, and was graduated from the Case Institute of Technology in Cleveland with a bachelor of science degree in 1910. In 1914, Case awarded him the degree of electrical engineer for his study of light-controlling glassware, and he later took postgraduate work at the Carnegie Institute of Technology, Pittsburgh, Pa., as well as at the University of Paris, France. In 1952 Case Institute awarded him the honorary degree of doctor of engineering. After operating an electrical contracting firm and working in Pittsburgh as a consulting engineer, Dr. Hibben joined Westinghouse in 1915 as a meter design engineer. Later he became an arc-lamp specialist at the East Pittsburgh works and later an illuminating engineer at sales headquarters. Hibben rejoined the company in 1919 as a supervisor in the Cleveland Lamp Division office after serving as a captain in the American Expeditionary Forces in World War I. In his active professional career Dr. Hibben has made many contributions to the science and art of illumination. He was the first to design mobile anti-aircraft searchlights (1917); the first to perfect a design for lighthouse lenses of American manufacture (1920); the first to design acceptable semi-indirect lighting fixtures, and a member of a group of scientists that developed the initial "cluster" street lights. He directed the designing of a system of transcontinental airway beacons in 1927, and also the first modern floodlighting for public monuments and for airports in 1928. He is an authority on the floodlighting of public sites and monuments, and his designs light the Statue of Liberty, the Washington Monument, Natural Bridge, Va., 1927; Holland Tunnel 1927, Carlsbad Caverns, Endless Caverns, Va., and Crystal Caves, Bermuda, 1937. He is a past president, secretary, and treasurer of the Illuminating Engineering Society. He was an engineering delegate from the United States to the Congress of the International Commission on Illumination in Paris in 1948, and in Stockholm in 1951. He is a member of many professional societies, including the British Illuminating Engineering Society and the Engineers Club of New York. He is a past president of the Montclair Society of Engineers. He is also recipient of the Westinghouse Order of Merit, the highest award bestowed by the company. He served on the Production and Application of Light Committee (1938–40, 1942–50, Chairman 1945–47.

O. G. Villard, Jr. (AM '42), associate professor of electrical engineering, Stanford University, Palo Alto, Calif., has been elected "Outstanding Young Bay Area Engineer of 1955." He was presented the award for his contributions to his profession and his community as well as for the general scope of his engineering activity, by the Bay Area Engineers' Week Committee. He became associate professor in 1952. Previously he had been acting assistant professor of electrical engineering in 1946; and assistant professor 4 years after that. He received his bachelor of arts degree from Yale magna cum laude in 1938. In 1948 he obtained both an electrical engineering and a doctorate degree from Stanford. He has also served on the staff of the Radio Research Laboratory, Harvard University, and has handled technical liaison between the laboratory and government bureaus in Washington, D. C.

J. J. Thomason, (AM '19, M '25) chief engineer, J. Frazer Smith and Associates, Memphis, Tenn., has become a Member for Life of the Institute. He became a Member of the Institute in 1919, while assistant chief engineer, South West Gas and Electric Company. Later he went into consulting practice, and then joined Westinghouse in 1923. He was lighting engineer, manager of Transportation, Industrial, and Central Station Divisions of the South West District of Westinghouse until 1939, when he became manager of the Memphis office. He retired from Westinghouse in 1953 and joined J. Frazer Smith, Architects and Engineers, Memphis, as chief engineer.

OBITUARY

Russell Wellesley Stovel (AM '02, Member for Life), retired, died recently after a long illness. Mr. Stovel was born in Toronto, Ont., Canada, and was graduated from McGill University (Montreal) "a gold medalist" and winner of the Prince of Wales scholarship. He had been associated with Westinghouse, Church, Kerr and Company for many years. Following the merger of that firm with Dwight P. Robinson, he joined Robinson. This was followed by an association with Gibbs and Hill, Inc., where he was in charge of many electrification projects. He was vice-president of Allied Engineers and served as a lieutenant colonel in France during World War I. Before he retired he was consulting engineer with the Public Service Commission of New York. Mr. Stovel had served on the following AIEE committees: Traction and Transportation (1920–22), Power Stations (1919–20), and Power Generation (1928–31).

Claude N. Rakestraw (AM '10, M '21, Member for Life), retired, Cleveland (Ohio) Electric Illuminating Company, died recently. Mr. Rakestraw was a past chairman of AIEE's Cleveland Section. Mr. Rakestraw joined Cleveland Electric Illuminating Company in September 1912 as a member of the sales department. He transferred to engineering work, and in 1916 became superintendent of underground lines. In 1934 he was made safety director with responsibility for all aspects of safety in the company's operation. He became supervisor of employee training in 1945 and staff assistant to the director of personnel in 1948. This was the position he held at the time of his retirement in 1950. He had an electrical engineering degree from University of Michigan. Mr. Rakestraw had served on the following AIEE committees: Transmission and Distribution (1920–23) and Safety (1938–45, 1948–50).

John Gustav Carroll (M '45), electrical engineer, Detroit (Mich.) District, Army Corps of Engineers, died on January 4, 1955. Mr. Carroll was born in Galveston, Tex., November 20, 1887, and was graduated from the Agricultural and Mechanical College of Texas in 1911 with a bachelor of science degree in electrical engineering. In 1912, after a year as engineering apprentice, he became an electrical engineer for the Westinghouse Electric Corporation (then the Westinghouse Electric and Manufacturing Company), East Pittsburgh, Pa. In 1920 he became chief engineer for the Walker Vehicle Company, Chicago, Ill., then a subsidiary of the Commonwealth Edison Company, and in 1927, manager, wholesale and apartment equipment sales, Northern District, Kelvinator, Chicago Corporation. Mr. Carroll joined the Philadelphia Storage Battery Company in 1929 as manager, power sales, for the Buffalo, N.Y., Detroit, and Kansas City territories, and in 1932 he became manager of operation for the Union Company, Detroit. He became associated with Government work in 1942 when he acted as engineer in charge of the Detroit District for the Production Service, War Production Board, and in 1943 he was made chief engineer, Smaller War Plants Corporation, for Region XI comprising the state of Michigan and four bordering Ohio counties. In 1949 he was an industrial consultant in Detroit, and in 1950 he became affiliated with the Army Corps of Engineers.

Carl Grover Jones (AM '16, M '18, Member for Life), Wise, Va., died recently. Mr. Jones had retired from the Youngstown (Ohio) Sheet and Tube Company in 1953. He was born in Beloit, Kans., in 1886, and was a 1909 graduate of Highland Park College in Des Moines, Iowa, where he earned a bachelor of science degree in electrical engineering. After a year in the student's course at the General Electric Company, he joined the company's research laboratory in Pittsfield, Mass., in 1911, where he remained until 1912 when he was transferred to the developmental section of the transformer engineering department. In 1915 he became affiliated with the Kuhlman Electric Company, Bay City, Mich., and in 1917 he entered the employ of the Westinghouse Electric Corporation (then the Westinghouse Electric and Manufacturing Company), East Pittsburgh, Pa., in the transformer engineering department. In 1931 he left his work as inductive engineer for Westinghouse to join the Youngstown Sheet and Tube Company. At the time of his death, Mr. Jones held a number of patents in the electrical field.

MEMBERSHIP

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before May 25, 1955, or July 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Brown A., Coles Signal Laboratory, SCEL, Fort Monmouth, N. J.
Bryan, J. K., Union Electric Co., St. Louis, Mo.
Carter, T. A., Aluminum Co. of Canada Ltd., Montreal, Que., Canada
Douglass, D., The Connecticut Power Co., Hartford, Conn.
Michaelis, M., Arthur D. Little, Inc., Cambridge, Mass.
Scott, N. S., University of Michigan, Ann Arbor, Mich.
Straughen, A. R., Department of National Defence, Naval Headquarters, Ottawa, Ont., Canada
Vokac, C. W., Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.
Wilkes, D. P., Western Electric Co., New York, N. Y.

9 to grade of Member

Recommended for Transfer

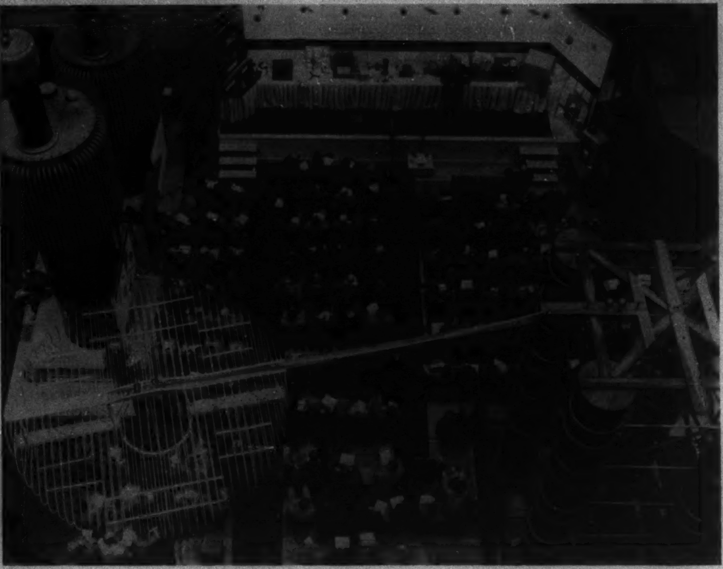
The Board of Examiners at its meeting of March 17, 1955, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Anderson, M. W., associate elec. engr., light dept., City of Seattle, Wash.
Boyd, R. C., application engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Bridler, F. W., supt. of production, El Paso Electric Co., El Paso, Tex.
Brown, F. D., area sales mgr., Westinghouse Electric Corp., Philadelphia, Pa.
Brown, W. C., partner, Blomquist & Brown, C. E., Salt Lake City, Utah
Bryan, C. E., chief engr., & asst. mgr., Jackson Electric Dept., Jackson, Tenn.
Carman, C. C., senior engr., Bechtel Corp., San Francisco, Calif.
Cockrell, B. D., elec. engr., Aluminum Co. of America, Rockdale, Tex.
Cook, B. J., personnel administration, Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Day, E. C., asst. secy., comm. on technical operations, American Institute of Electrical Engineers, New York, N. Y.
Eller, W. H., professor of physics, University of Hawaii, Honolulu, T. H.
Ewen, R. A., engineer, General Electric Co., Canton, Ohio
Farinholt, W. W., sales engr., General Electric Co., Atlanta, Ga.
Frans, W. D., asst. to area engineer, Bonneville Power Adm., Seattle, Wash.
Fullerton, F. W., senior engineer, Southwestern Bell Telephone Co., Oklahoma City, Okla.
Garmezy, R. H., head of radiator lab., Blackstone Corp., Jamestown, N. Y.
Gollin, N. W., research engr., Taylor Instrument Companies, Rochester, N. Y.
Guernsey, E. D., foreign wire relations engr., The Ohio Bell Telephone Co., Columbus, Ohio
Hammer, W. A., Jr., relay & meter engineer, Pennsylvania Water & Power Co., Lancaster, Pa.
Heckman, C. J., power service engr., Dallas Power & Light Co., Dallas, Tex.
Hickman, F. B., branch manager, Westinghouse Electric Supply Co., Savannah, Ga.
Hill, C. F., electrical engineer, Vern E. Alden Co., Chicago, Ill.
Hogan, D. L., electronic engineer, National Security Agency, Washington, D. C.
Hong, K. S., chief electrical engineer, Moore Dry Dock Co., Oakland, Calif.
Kallenbach, G. K., operating supt., Niagara Mohawk Power Corp., Albany, N. Y.
Kenyon, G. H., project engineer, technical products div., Corning Glass Works, Corning, N. Y.
Kritscher, A. J., electrical engineer, San Francisco Public Utilities Comm., San Francisco, Calif.
Leoni, L. C., development engineer, General Electric Co., Pittsfield, Mass.
Lunge, G. S., senior application engineer, General Electric Co., Schenectady, N. Y.
Markarian, P. B., electrical distribution engineer, The Scranton Electric Co., Scranton, Pa.
Marston, F. M., engineer, Bell Telephone Co. of Pa., Pittsburgh, Pa.
McKee, F. L., station engineer, Public Service Co., Salisbury, Md.
McKune, W. J., assoc, prof. of elec. engg., Georgia Institute of Tech., Atlanta, Ga.
McLean, H. T., engineer, General Electric Co., Schenectady, N. Y.
Miller, R. M., supervisory electrical engineer, Bureau of Reclamation, Denver, Colo.
Olson, O. E., electrical design engineer, Electric Machinery Mfg. Co., Minneapolis, Minn.
Opdenweyer, A. E., engineer, Portland General Electric Co., Portland, Oreg.
Procopio, R. G., engineer, Sperry Gyroscope Co., Lake Success, N. Y.
Radke, D. F., development engineer, General Electric Co., Pittsfield, Mass.
Rafsnider, L. B., engineer, The Ohio Bell Tel. Co., Columbus, Ohio
Rhudy, R. G., supervisor, General Electric Co., Schenectady, N. Y.
Rigie, B., chief, systems section, Ketay Laboratories, New York, N. Y.
Roberts, L. J., gas & water supervisor, Southwestern Public Service Co., Amarillo, Tex.
Rosenberry, G. M., Jr., development engr., General Electric Co., Schenectady, N. Y.
Ross, G. A., manager, Thomson Laboratory, General Electric Co., West Lynn, Mass.
Sanborn, C. B., Jr., electrical engineer, The Electric Controller & Mfg. Co., Cleveland, Ohio
Sargent, H. C., general superintendent, Superior Water, Light & Power Co., Superior, Wis.
Schneider, B. H., stations engineer, The Detroit Edison Co., Detroit, Mich.
Schneider, D. B., supervisor, specialty control dept., General Electric Co., Schenectady, N. Y.
Slaybaugh, G. D., partner—Slaybaugh-Thompson Co., Denver, Colo.
Small, R. W., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Smith, H., special engineer, El Paso Electric Co., El Paso, Tex.
Smith, W. R., senior engineer, Southwestern Public Service Co., Plainview, Tex.
Sullivan, E. M., president, E. M. Sullivan Electrical Engineering, Springfield, Mass.
Temoshok, M., application engineer, General Electric Co., Schenectady, N. Y.
Timpe, N. B., electrical engineer, Philadelphia Electric Co., Philadelphia, Pa.
Tomsic, E. M., electrical engineer, Bureau of Reclamation, Denver, Colo.
Verheyden, V. E., engineer, General Electric Co., Schenectady, N. Y.
Walkup, J. F., engineer, Bechtel Corporation, San Francisco, Calif.
West, W. K., asst. superintendent, Aluminum Co. of America, retail power div., Alcoa, Tenn.
Willyoung, D. M., engineer, General Electric Co., Schenectady, N. Y.
Wulfsberg, A. H., head, engg. & research group, Collins Radio Co., Cedar Rapids, Iowa

62 to grade of Member

OF CURRENT INTEREST



General view of lecture-demonstration by Dr. Astin in the NBS High-Voltage Laboratory.

National Bureau of Standards Exhibits New Scientific Developments at Open House

ANNOUNCEMENT of a system for "X-ray televising" the internal parts of an operating engine, the demonstration of a radiation monitor for atomic blasts, and recent developments in the science of measurement were among the highlights of an Open House at the National Bureau of Standards (NBS), Washington, D. C. The program stressed the significance of physical measurement standards to scientific and industrial progress and featured the first showing of two new radiation facilities: the NBS Betatron and Gamma Ray Laboratories. The Open House guests were also taken on guided tours covering the work of 14 other NBS Laboratories.

The new Gamma Ray Laboratory will permit the Bureau to meet increasing scientific and technical demands growing out of advances in the use of atomic energy. Before radioactive materials and instruments for their detection can be used safely and effectively, they must be calibrated against the radioactive standards maintained by the Bureau. In recent years, the isotope Cobalt 60 has been increasingly used in place of radium for industrial X-ray photography, medical treatment, and instrument calibration. The Gamma Ray Laboratory was built to accommodate the growing demand for Cobalt-60 calibration. The laboratory also maintains radium standards for calibration of all medical radium preparations.

The Betatron Laboratory houses the Bureau's 50-million-volt betatron and 180-million-volt synchrotron. The Bureau is using the X rays produced by these high-energy electron accelerators to develop the standards and measurement methods needed for safe application of high-energy X rays in medicine, industry, and nuclear physics. Exact wall thicknesses and optimum types of construction for protection from these deeply penetrating radiations can be determined through laboratory research.

Before touring the Bureau, the guests assembled in the Bureau's High-Voltage Laboratory to witness a lecture-demonstration by Dr. Allen V. Astin, director of the Bureau. In his talk, "Physical Standards—The Cornerstone of Scientific and Industrial Progress," Dr. Astin used the electromagnetic spectrum to bring out the relationship between the Bureau's activities and the technological economy of the nation. Illustrating his remarks with actual operating apparatus, he discussed the Bureau's work in developing the precise standards of measurement required by modern science and industry in the various ranges of the spectrum.

Starting with the national standard meter bar and kilogram—on public exhibition for the first time—Dr. Astin went on to discuss the hundreds of physical measurement standards which the Bureau has derived from these basic standards since its establishment in 1901. He chose an ordinary electric lamp as an example of a modern technological product and showed how its uniform quality is related in ten different ways to activities carried on by the Bureau. Included are NBS activities which provide standards for measurement of brightness, color, electrical resistance, watt rating, and voltage rating. Also involved are NBS standard samples of the lamp materials—brass, glass, and tungsten; screw thread standards to insure proper fitting of lamp and socket; specifications for lamp quality; and standard electrical safety codes for power systems and for lamp sockets and wiring.

Dr. Astin illustrated NBS work in the X-ray range of the spectrum with demonstrations of the radiation monitor and the system for X-ray televising the interior of an engine. The radiation monitor is a remote-control system which automatically measures radia-

DR. ASTIN explains how the uniform quality of an electric lamp is related to NBS work. Behind him is a chart of the electromagnetic spectrum. At the extreme left of the stage are the national standards of length and mass—the meter bar and kilogram. At right is a radiation monitor for remote detection of radiation from atomic blasts.

EXPERIMENTAL setup used for X-ray televising the internal parts of an operating mechanism. A compressor to be examined is shown in position on the black cloth.

tion intensities in the vicinity of an atomic explosion and transmits the data by radio to a centrally located headquarters.

The X-ray televising demonstration used highly penetrating radiation from the Betatron in combination with a technique recently developed at the Bureau for converting high-energy X rays into visual images. The audience saw clearly the moving piston, piston rod, and other parts in the televised X-ray image of a small 1-cylinder engine. By means of this technique it should be possible to televise the internal operation of a wide range of mechanisms, such as automotive and aircraft engines, pumps, and other devices.

Because of their greater penetrating power and lower scattering, high-energy X rays from Betatrons and Synchrotrons produce sharper images than do lower energy X rays, allowing the observation of greater detail and the detection of more minute flaws in metallic equipment. However, until now their use in studying the internal operation of heavy machinery has been confined largely to X-ray photographs. Suitable methods for observing the interior of a mechanism while it operates have been lacking.

The Bureau's system, developed by Dr. J. S. Pruitt of the NBS Betatron Laboratory, makes use of an instrument called a pattern amplifier which acts as an X-ray intensifier, continuously detecting, amplifying, and displaying low-intensity X-ray images. The major component of the pattern amplifier is the converter, a large cylindrical thallium-activated sodium-iodide crystal which converts X-ray images into optical images. When bombarded with an X-ray beam, the crystal emits visible light. If the flat faces of the crystal are perpendicular to the X-ray beam, a visible replica of the X-ray image may be observed along the beam axis. When the pattern amplifier is used in conjunction with a high-intensity high-energy X-ray source, such as the NBS Synchrotron, it can continuously display images of parts hidden by as much as 18 inches of steel or 7$^1/_2$ feet of concrete. The visual image may be observed directly by eye, photographed with an ordinary camera, or observed with a remotely controlled television camera.

In discussing work in the radio range, Dr. Astin announced that the Bureau is working with the Air Force and the Navy Bureau of Aeronautics in setting up a recalibration center to insure the reliability and efficiency of electronic equipment in military aircraft. About half the cost of a modern fighter airplane now goes into electronic devices for navigation, communication, fire control, and other purposes. In order for this equipment to work together as a unit, each of the separate components must be specified, constructed, and evaluated according to certain reference standards. The recalibra-

METAL FATIGUE research is being carried on by the Bureau. The machine in the left foreground applies an axial "push-pull" to specimens of rod. Behind the axial-load machine and in the right foreground are rotating-beam devices for rods. On the table is a rotating-bending and reverse twisting machine for wire.

STANDARDS demonstration at the NBS Open House. Equipment at right is for precise calibration of master watt-hour meters submitted by power companies' and public utilities' commissions. The meters are compared with the Bureau's standard watt-hour meter (circular housing), behind which is timing and counting equipment.

ATOMIC FLAME apparatus demonstrated at the NBS Open House. The Bureau hopes to learn more about the burning process so that fuels may be used more efficiently. Measured temperature within the flame varies from 1,200 F to 20,000 F, depending on the method of measurement used.

tion center will periodically calibrate the working standards used in maintaining it.

One of the demonstrations in the visible range of the spectrum concerned 3-color brightness standards now under development at NBS for the television industry. Color television tubes contain red, green, and blue fluorescent materials, which in combination produce all the required colors in the image. The Bureau's standards are for use in measuring the brightness of the three components. The visitors saw the television standards in the form of squares of transparent colored glass, lighted from behind. The colors match closely those used in color television tubes.

In addition to the Gamma Ray and Betatron Laboratories, the guests saw demonstrations by NBS laboratories concerned with precision measurement of length, measurement problems at supersonic speeds, standards and measurement at very high temperatures, fatigue of metals, properties of matter at very low temperatures, high-speed electronic computers, color and its measurement, electrical standards and measurement, precise analysis of metals and alloys, properties of heat-insulating materials, measurement of forces up to 10 million pounds, radio propagation research, atomic structure of crystalline materials, and high-speed impact properties of fibrous materials.

New Tube That Simulates Typesetting Translates Codes at 100,000 Words Per Minute

A NEW electron-image tube that can translate coded signals from tape, keyboard, or radio into clearly defined letters and figures at speeds up to 100,000 words per minute for high-speed photographic recording has been announced by the Radio Corporation of America (RCA).

The new tube, developed at the David Sarnoff Research Center of RCA, fills an acute need for high-speed printing devices operating directly from data in coded form. When it achieves commercial form, its initial application is likely in electronic message transmission and computing systems. Further development is expected to fit it for wider application in general printing as an electronic means of typesetting.

In operation, the tube simulates typesetting in selecting letters and figures one by one from a "font" and placing them in luminous form on the 5-inch circular cathode-ray-tube face, either in lines or in any pattern desired. The ability to place the characters where they are wanted gives the tube wide flexibility for such tasks as producing financial statements, balance sheets, and bills, where letters and figures must be placed in various positions on a form.

The font from which characters are selected is a lantern slide bearing a chart of letters and figures which are projected from outside the tube onto a sensitive layer at the rear of the tube. Any of a variety of slides may be used, permitting selection from a wide range of type styles for reproduction on the tube face.

The new image tube was developed by W. H. Bliss and J. E. Ruedy under the supervision of C. J. Young and Dr. G. A. Morton, of the technical staff at the David Sarnoff Research Center. It is 25 inches long and resembles in appearance the cathode-ray tubes used in oscilloscopes. Its operation, however, is substantially different.

The layer at the rear onto which the slide is projected consists of photoemissive material, which emits a stream of electrons in the pattern of the projected letters and figures. The electron stream, carrying all of this information, is accelerated forward in the tube by a voltage applied to the wall coating of the tube.

The selection of letters and figures in the required order is accomplished with a tiny aperture at the neck of the tube, permitting only one character at a time to pass through. As the electron stream moves toward the aperture, a magnetic deflection coil around the outside of the tube shifts the stream so that the desired character passes through the aperture and speeds toward the tube face. Another set of magnetic coils then focuses and deflects the character to its proper place on the face, where it appears in visible form on a phosphor screen. As many as 4,000 characters have been produced clearly in a single pattern on the tube face. The second set of coils is capable, however, of varying the size of the letters and figures on the screen if enlargements of these characters are required.

The entire process of selecting the character, passing it through the aperture, and placing it in the right location on the tube face can take place at speeds up to 10,000 letters a second. This depends upon the rate at which coded information is fed into the circuits controlling the tube.

The source of the coded information can be perforated paper tape, magnetic tape, wire or radio signals, keyboard selection, or an electronic storage unit such as a magnetic memory. In tests of the tube at RCA Laboratories, the source has been a perforated tape like those used in teleprinter circuits. In any case, the coded input can control both the selection of the characters and their location on the face of the electron-image tube.

Since the image on the tube face is to be recorded on photographic film, the new image tube has been designed to produce letters and figures with clear definition and a high level of brightness. In laboratory tests 2,000 characters per second have been recorded from the tube face on standard 35-mm film. For higher speeds, films of greater sensitivity are required.

TRADIC is shown in operation by J. H. Felker (left), who gives instructions to the computer, and J. R. Harris (right), who places numbers into the machine.

Bell Telephone Laboratories Develops All-Transistor Computer for Air Force

A MINIATURE electronic "brain" that opens a new era in computers and that can operate flawlessly in airplanes flying at supersonic speed has been developed for the U. S. Air Force by Bell Telephone Laboratories, Inc.

This digital computer eliminates vacuum-tube failure and heat, jet aircraft's greatest electronic problems, by the use of transistors instead of vacuum tubes. It contains nearly 800 of these devices and is believed to be the first all-transistor computer designed for aircraft.

The new computer, known as TRADIC (TRAnsistor-DIgital-Computer), requires less than 100 watts to operate. This is 1/20th of the power needed by comparable vacuum-tube computers. Early computers used as many as 18,000 vacuum tubes and frequently required several kilowatts to operate.

The new electronic "brain" contains, in addition to transistors, nearly 11,000 germanium diodes. These serve as the electronic equivalent of tiny 1-way switches. Solid, like transistors, they are capable of operating thousands of times faster than their mechanical counterparts.

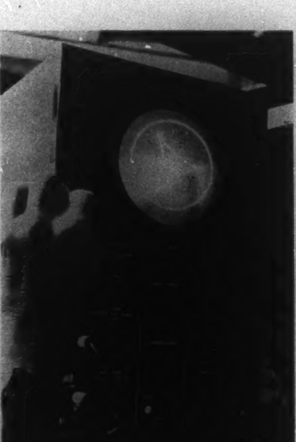
When design work has been completed, the computer will probably occupy less than 3 cubic feet of the critical space in modern military aircraft.

The new general-purpose computer was developed at Bell Laboratories under the direction of J. H. Felker, electrical engineer, who is in charge of a group of electrical and mechanical engineers developing transistor circuits for military applications.

TRADIC can do 60,000 additions or subtractions, or 3,000 multiplications or divisions a second. A typical problem fed into the machine requires it to go through about 250 different steps of computation. It can run through an entire problem of that complexity and provide an answer in about 15/1,000ths of a second. The computer can handle, simultaneously, as many as 13 16-digit numbers.

Mathematical instructions are placed into TRADIC by means of a plug-in unit resembling a small breadboard. Plug-in units are set up beforehand with interconnecting wires to represent problems at hand. Numbers to be processed are put into the machine by means of simple switches.

The laboratory model of TRADIC provides answers to trigonometric problems with a series of dots on an oscilloscope. These



LABORATORY model of TRADIC can provide answers to trigonometric problems with a series of "dots" on an oscilloscope.

Future Meetings of Other Societies

National Metal Trades Association, Western Plant Management Conference. May 1–4, 1955, French Lick Springs Hotel, French Lick, Ind.

Electrochemical Society. May 1–5, 1955, Sheraton-Gibson Hotel, Cincinnati, Ohio

British Industries Fair. May 2–13, 1955, Birmingham, England

Society of American Military Engineers, Annual Meeting. May 5–6, 1955, Hotel Waldorf-Astoria, New York, N. Y.

l'Institut Montefiore (AIM), International Meeting for Study of Industrial Applications of Nuclear Energy. May 3–4, 1955, Liege, Belgium

Pennsylvania Electric Association. *Transmission and Distribution Committee,* May 5–6, 1955, Irem Temple Country Club, Dallas, Pa. *Hydraulic Power Committee,* May 5–7, 1955, Hotel Sheraton-Brock, Niagara Falls, Ont., Canada. *Systems Operation Committee,* May 12–13, 1955, Skytop Lodge, Skytop, Pa. *Electric Equipment Committee,* May 19–20, 1955, Hotel Roosevelt, Pittsburgh, Pa.

Society of American Military Engineers, Annual Meeting. May 5–6, 1955, Hotel Waldorf-Astoria, New York, N. Y.

American Association of Spectographers, 6th Annual Conference. May 6, 1955, Engineers' Building, Chicago, Ill.

Society of Plastics Industry, Annual Meeting and Conference. May 7–15, 1955, Cruise on *Queen of Bermuda*

Northwest Electric Light and Power Association, Business Development Section, Meeting. May 9–11, 1955, Hotel Utah, Salt Lake City, Utah

Metal Power Association, National Meeting and Show. May 10–12, 1955, Bellevue-Stratford Hotel, Philadelphia, Pa.

Chicago Electric Industry Show, Annual Show. May 10–12, 1955, Conrad Hilton Hotel, Chicago, Ill.

Pacific Coast Electrical Association, Annual Convention. May 11–13, 1955, Sheraton Palace Hotel, San Francisco, Calif.

Public Utilities Advertising Association, Annual National Convention. May 12–13, 1955, Sheraton Hotel, Chicago, Ill.

New York State Society of Professional Engineers. May 12–14, 1955, Commodore Hotel, New York, N. Y.

Michigan State College, Symposium on Automation. May 13, 1955, Engineering School, East Lansing, Mich.

American Materials Handling Society, National Materials Handling Exposition. May 16–20, 1955, International Amphitheater, Chicago, Ill.

Armed Forces Communications and Electronics Association, Annual Convention. May 19–21, 1955, Hotel Commodore, New York, N. Y.

National Association of Electrical Distributors, 47th Annual Convention. May 22–26, 1955, Conrad Hilton Hotel, Chicago, Ill.

American Society for Quality Control, Annual Meeting. May 23–25, 1955, Hotels Statler and New Yorker, New York, N. Y.

American Management Association, General Management Conference. May 23–25, 1955, Hotel Roosevelt, New York, N. Y.

Signal Corps Engineering Laboratories, Ninth Annual Frequency Control Symposium. May 25–27, 1955, Hotel Berkeley-Carteret, Asbury Park, N. J.

Basic Materials Exposition, Design Engineering Show. May 31–June 3, 1955, Convention Hall, Philadelphia, Pa.

National Society of Professional Engineers, Annual Meeting. June 2–4, 1955, Bellevue-Stratford Hotel, Philadelphia, Pa.

TRANSISTOR, one of almost 800 used in the new Bell air-borne digital computer, is inserted into a "memory" package. Actual packages will be about one half the size of the model shown.

dots of light move so rapidly that they actually appear to draw geometric diagrams on the scope.

To handle the successive steps of complex computation, TRADIC automatically transfers each subanswer to built-in memory packages while continuing to calculate the remaining sections.

University of Michigan Offers Nuclear Reactor Summer Course

The University of Michigan announces a 2-week intensive course on "Nuclear Reactors and Radiations in Industry" to be given in Ann Arbor, August 15–26, 1955. The course is sponsored by the Nuclear Engineering Committee of the College of Engineering, and will be conducted by members of the Engineering College staff, assisted by guest lecturers. Staff members participating include Professors L. E. Brownell, H. J. Gomberg, W. Kerr, H. A. Ohlgren, and J. R. Sellars.

Lectures covering such topics as elementary nuclear theory, measurements of nuclear radiations, interaction of radiation and matter, and nuclear reactors and fuels will be co-ordinated with laboratory demonstrations, tours of university radiation facilities, and examples of industrial applications. Guest lecturers from industry will present current progress and thinking in the nuclear field. The 1-megawatt University of Michigan research reactor, which will be under construction during the course, will be inspected and discussed. Demonstrations using a multikilocurie gamma radiation source will be conducted. The course is intended for the engineer without previous experience in nuclear technology who wishes to acquire a knowledge of representative problems and techniques in this rapidly developing field.

Tuition will be $200. The fee includes a complete set of printed course notes.

For further details or for information on application, write Professor William Kerr, Department of Electrical Engineering, University of Michigan, Ann Arbor. The deadline for registration is June 1, 1955.

Armour to Have First Nuclear Reactor Designed for Private Industrial Research

THE FIRST nuclear reactor designed for private industrial research will be built for the Armour Research Foundation by North American Aviation, Inc., it was announced recently.

It is proposed to locate the new reactor at Armour's operations on the campus of the Illinois Institute of Technology in Chicago, not far from the site of the historic Stagg Field reactor which heralded the modern atomic age. Unlike the Stagg Field machine, the new industrial research reactor will be used entirely for nonmilitary applications of atomic energy.

Construction will begin when the project has been approved by the Atomic Energy Commission (AEC). Fissionable material for the operation of the reactor has been requested from the AEC under the licensing provisions of the AEC Act of 1954. The reactor and associated equipment are expected to cost about $500,000.

Short-lived radioisotopes, useful in medical, industrial, and scientific research, will be available locally from the new machine. Such short-lived isotopes have not been widely used because of the time delay and resultant radioactivity loss if moved over long distances.

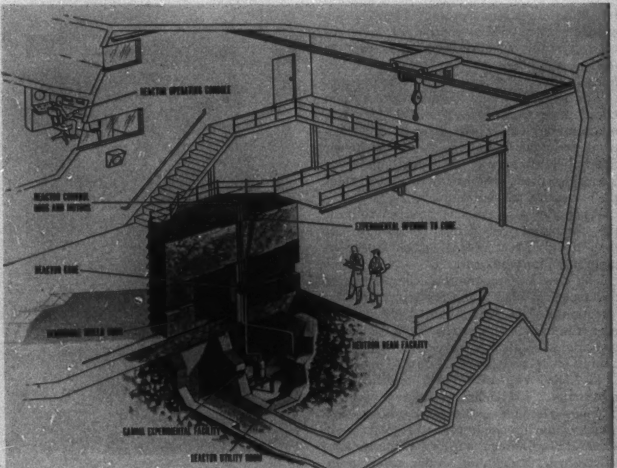
Scheduled to be completed in about a year, the reactor will be available to industrial and government sponsors to conduct a wide range of nuclear research. Capable of operating at a power level of 50,000 watts, the reactor will produce neutrons and gamma radiation for research and development in the fields of biology, metallurgy, food processing, electronics, chemistry, textiles, oil and gases, rubber and leather, machinery, building materials, and allied industrial and scientific pursuits.

The reactor will be located in a room about 48 feet long, 72 feet wide, and 30 feet high. Atomic fission willl take place in the reactor core, a steel sphere about 1 foot in diameter. The sphere will contain about 4 gallons of uranyl sulphate, enriched in Uranium 235, in a water solution. Because of this arrangement the reactor is called a "solution type."

The reactor core will be surrounded by an 8- by 5- by 5-foot stack of graphite bars which act as a reflector. The graphite stack is completely enclosed in a steel tank, except for those areas opened to permit access to the radioactivity and neutron supply from the core. Five-foot-thick dense concrete blocks form the exterior shield for the machine, giving an over-all dimension of 18 feet long, 16 feet wide, and 11 feet high for the shielded reactor structure.

Rate of fission in the reactor will be controlled by four boron rods. These rods, when placed near the reactor core, absorb neutrons, thus stopping the fission process. When the rods are withdrawn fission begins again. With this control it is possible to operate the reactor at various power levels by regulating the rate of fission.

A particular feature of this reactor is its self-contained design which confines all the radioactivity within the shield. No fumes, gases, smoke, or any other materials will be exhausted or discharged from the machine. This design, together with the inherent safety features of the solution-type reactor,


REACTOR OPERATING CONSOLE
REACTOR CONTROL RODS AND MOTORS
EXPERIMENTAL OPENINGS TO CORE
REACTOR CORE
REMOVABLE SHIELD BLOCK
NEUTRON BEAM FACILITY
GAMMA EXPERIMENTAL FACILITY
REACTOR UTILITY ROOM

ARTIST'S SKETCH of the first nuclear reactor for private industrial research which North American Aviation designed and will build for Armour Research Foundation, Chicago.

make it particularly suitable for the Armour research program.

Fissionable material to fuel the reactor will be obtained from the Atomic Energy Commission on an "extended-loan" basis. Armour officials have pointed out that sponsored research with the machine will be subject to no competition from military applications, no secrecy of any kind other than that called for in the protection of the individual sponsors' programs. The machine will not be used for research on reactors, nor will the reactor be utilized for the generation of electric power.

Varian's New Magnetometer Utilizes Hydrogen Nuclei to Detect Mineral Deposits

A SIMPLE BOTTLE of water will greatly speed exploration of what lies beneath the earth's surface.

A contract announced recently revealed that exclusive world-wide rights for the Varian Earth's Field Magnetometer have been granted to Hycon Aerial Surveys of Pasadena, Calif. With this contract, Hycon Aerial Surveys becomes a separate corporation in which both Hycon Manufacturing Company and Varian Associates hold ownership interest.

The Varian magnetometer uses the inherent properties of hydrogen nuclei, contained in any sample of tap water, to detect and measure minute changes in the earth's magnetic field. The announcement was made jointly by A. E. Acker, president of Hycon Aerial Surveys, Inc., and Russell Varian, president of Varian Associates.

Acquisition of the Varian magnetometer will enable Hycon Aerial Surveys, Inc., to render an improved analysis of the earth's natural resources on flights that simultaneously map the area under study.

The Varian magnetometer operates on a fundamentally new concept of physics that will open up unlimited fields of air-borne geophysical exploration. The new instrument uses hydrogen nuclei to record minute changes of the earth's magnetic field which in turn can indicate the presence of minerals or petroleum deposits.

Since the Varian instrument is calibrated on a constant of nature, the hydrogen atom's nucleus, it is independent of any outside reference point. This feature makes the new magnetometer extremely simple to build and maintain. Weight- and space-saving features of the new unit are particularly important in air-borne surveys and small versions of the Varian magnetometer need weigh no more than 100 pounds, excluding the primary power supply.

One of the most important advantages of the Varian magnetometer is that it needs no gyroscopic stabilization to obtain absolute readings of total field. The "bird" that is trailed behind the survey airplane measures total magnetic field without regard to direction. The "bird" that feeds basic information to the recording equipment in the airplane is little more than a jar of water with a coil wrapped around it housed in a streamlined cone. Relatively inexpensive to build, there is negligible loss if the pilot comes too close to the ground and smashes the jar of water and coil. Since it can be carried by helicopter or muleback without complicated reference devices, the Varian instrument will lead the way to valuable deposits previously out of the range of existing detection equipment.

IRE Annual Convention and Exhibition

THE INSTITUTE OF RADIO ENGINEERS held its 43d annual convention and exhibition at the Waldorf-Astoria Hotel and Kingsbridge Armory and Palace, New York, N. Y., March 21–24, 1955. A program of more than 275 technical papers were presented at 55 sessions and more than 40,000 persons visited the 704 exhibits at the Armory, shown above.

AT & T Installs Microwave Horn-Reflector Antenna

A new type of microwave antenna, designated "horn-reflector," was recently installed by the long lines department of the American Telephone and Telegraph Company at a station near Terrell, Tex. This is the first commercial installation of these super-capacity antennas. They will be used on a route now under construction between Dallas, Tex., and Jackson, Miss., for telephone and television service.

Horn-reflector antennas, which are to replace the so-called "delay lens" antennas used on most Bell System radio-relay routes, operate over a very broad frequency band. A single antenna will be able to handle simultaneous transmission in the common carrier band of 3,700–4,200 mc and also in bands in the 6,000- and 11,000-mc regions.

Eventually, it will be possible for this antenna to handle 15,000 telephone conversations and ten television programs at the same time. Another advantage of the new antenna is that it is capable of transmitting simultaneously both horizontally and vertically polarized waves. This feature will be used to reduce crosstalk coupling between adjacent channels on the systems.

The horn-reflector antenna consists of a feed horn, an expanding horn-shaped casing, and a section of a parabolic reflector facing the mouth of the horn. The aperture of the horn has a cross section of 65 square feet. The energy from the radio equipment is transmitted through a circular waveguide to the feed horn which has a smooth transition from the 2.8-inch inside diameter of the waveguide to the 11.6-inch square aperture of the feed horn.

In transmitting, the radio waves leave the waveguide, expand in the feed horn and lower portions of the antenna, and are then reflected in parallel lines from the surface of the parabolic reflector. In receiving, the operation of the antenna is reversed. Incoming waves arrive in parallel lines and are reflected by the section of the parabola to the focal point in the feed horn and then through the waveguide to the radio equipment.

The approximate gain of the horn-reflector antenna as compared with an isotropic radiator, ranges from about 39 db at 4,000 mc to 48 db at 11,000 mc. The front-to-back ratio ranges from about 71 db to 78 db, depending on frequency band and polarization. The gain in the 4,000-mc range is about the same as the delay lens antenna.

Bell Labs and MIT Send UHF Signals 200 Miles

Direct television and multichannel telephone transmission through space for as far as 200 miles—without relay stations and at ultrahigh frequencies—has been accomplished, according to a recent announcement by Bell Telephone Laboratories and the Massachusetts Institute of Technology (MIT).

Television pictures, as well as radio and telephone conversation, can be sent "over the horizon" on ultrahigh frequencies, in an extension of a transmission technique recently applied to the continental defense system.

Principal virtue of over-the-horizon transmission is that longer communications bridges are possible over water and rugged terrain. In the present microwave-radio-relay network across the United States, relay stations are 30 miles apart.

Standard AM radiobroadcasting employs waves that follow the earth's curvature, but waves used in television and telephone relays were presumed to travel in a straight line. For many years, line-of-sight transmission between antennas placed on towers on the horizon (about 30 miles apart) was thought to be the only practical means of transmitting by radio the wide bands needed for television and multichannel telephone service.

This was disproved after years of research at MIT and Bell Telephone Laboratories. The latter's research stemmed from Bell's success with transcontinental microwave systems for carrying telephone conversations and radio and television programs from coast to coast and their continued interest in radio propagation. The MIT interest was stimulated by work for the Government in radar and overseas broadcasting.

Scientists knew that ultrahigh frequencies traveled over the horizon under certain conditions but believed them to be too weak and undependable for practical use. In the course of investigating occasional interference attributed to these waves, however, the scientists discovered that many actually overshot the relay towers at which they were aimed and arrived at farther points with remarkable consistency.

The next step was to provide reliable long-distance transmission over the horizon. MIT and Bell Laboratories engineers did this by erecting larger antennas and using higher power than is employed in the conventional microwave system. Thus, they put to use the weaker signals that drop off a straight radio beam beyond the horizon and are reflected or scattered to distant points by the atmosphere.

The effect of the new system is very much like that of a powerful searchlight, which casts a beam in a straight line. A searchlight aimed at the sky can be seen from the ground miles away, even when the searchlight is behind a hill. This is possible because some of the light is reflected to the ground by the atmosphere.

In order to make use of over-the-horizon transmission, 10-kw transmitters and 60-foot-diameter antennas are being used. This is 20,000 times the power and 30 times the antenna area used in the present transcontinental microwave system. It was found necessary to employ the lower frequencies (in the uhf band) to develop with available equipment sufficient power to attain a satisfactory degree of reliability.

Even after scientists learned that transmission was possible over the horizon, they were not certain that this medium would support the broad band of frequencies needed for multichannel telephone or television transmission. In the fall of 1953, they found that they could transmit 12 voice channels over the horizon.

Television was first successfully transmitted over the horizon in 1954 between the Holmdel, N. J., laboratory of the Bell Telephone Laboratories and the MIT Round Hill Research Station near New Bedford, Mass., a distance of 188 miles.

Bell and MIT scientists emphasize that this success with over-the-horizon transmission will probably result in a supplement to, rather than a replacement of, line-of-sight radio-relay systems.

Over-the-horizon signals are not to be confused with a similar type of transmission known as "ionospheric scatter," which is useful in long-distance transmission of telegraph signals at relatively low frequencies. Unlike ionospheric signals, the over-the-horizon technique provides signals that are useful for the wideband widths required for a television picture or by many telephone channels.

TWO ANTENNAS, one 28 feet and one 5 feet in diameter, at the MIT station near New Bedford, Mass., used in receiving over-the-horizon television from the Bell Laboratories station at Holmdel, N. J., 188 miles away. The larger of the antennas was destroyed by one of the hurricanes which took place last year.

11 European Nations Ratify Nuclear Research Treaty

Eleven nations have ratified the Convention of the European Organization for Nuclear Research. This UNESCO-sponsored treaty, adopted July 1, 1953, by representatives of 12 countries, went into effect on September 29, 1954. Nations which have ratified it are Belgium, Denmark, France, German Federal Republic, Greece, Netherlands, Norway, Sweden, Switzerland, The United Kingdom, and Yugoslavia. In the 12th country, Italy, ratification procedures have begun.

The European Organization for Nuclear Research (known as CERN from its French title, Centre European pour la Récherché Nucleaire) is now at work at its Geneva, Switzerland, headquarters, with a staff headed by Felix Bloch, Swiss-born Nobel prize-winner who until recently headed the Institute of Physics at Stanford University.

There will be nothing secret about CERN's work. This first demonstration of international collaboration in atomic research will serve all science in the effort to make good use of the secrets of the atom.

Michigan State Offers Symposium on Automation

Michigan State College, the first of the land-grant colleges in the United States, commemorates its centennial this year. For its contribution to the centennial program, the School of Engineering is sponsoring on May 12 and 13, 1955, the sixth of a series of ten academic symposia as a means of focusing attention on automation, one of the most important developments in its entire field of engineering. This Centennial Engineering Symposium is planned to be one of broad national interest with programs built around a series of general sessions of interest to all branches of engineering and a concurrent series of meetings sponsored by the seven individual departments of the school.

The general symposium theme will be "Automation—Engineering for Tomorrow." This latest and powerful tool of the engineer will be surveyed from its lowly beginnings through its present accelerating and far-ranging development to its unlimited future potentialities in the decades to come. General sessions held on the morning of May 13 will be devoted to presentation of two topics for discussion, "Automation—to Date" and "Development of Automatic Production Facilities." Luncheon and banquet speakers will include Dr. W. R. G. Baker, vice-president, General Electric Company, and Dr. Eric A. Walker, dean of engineering, Pennsylvania State University. Dr. Baker will speak on "Automation as an Engineer Sees It," developing his subject from the technical point of view. Dean Walker will discuss "Automation—a Look Into the Future" from the philosophical or sociological point of view.

On the afternoon of May 13 each department of the School of Engineering, including those departments holding a more comprehensive 2-day meeting, will sponsor its own concurrent series of meetings on those special themes of automation which will be of considerable interest to men in its particular field. These meetings will present as speakers many well-known designers and engineers in widely diversified fields. Talks, discussions, and panel sessions will be conducted by these authorities. Participation by representatives of national and state professional associations, societies, and manufacturing groups is assured.

Airlines Flight Dispatch Uses Automatic Reservation Device

American Airlines announced recently that it has begun to use its Magnetronic Reservisor, the world's first fully automatic reservations device, to solve another of transportation's problems—the furnishing of quick accurate airplane arrival and departure information to its passengers and the general public.

The reservisor will continue its main job—electronic and magnetic control of reservations in the New York area for the air line (*EE, Aug '52, p 768*) while it takes on this new task. The addition of "FLIFO" (trade name for flight information) will bring into action a hitherto unused portion of the reservisor's "memory."

Flight dispatch, using a special keyboard, transmits arrival and departure information directly into the reservisor. Basic facts are sent in on a regular schedule, and revisions are made as needed. Each transmission, naturally, takes just a fraction of a second to complete. The memory, then, is loaded and ready for questions.

If an agent in the main reservations room receives a telephone query, she keys her set for the flight in question, and then by pressing a set of twin buttons changes the set from a reservation-maker to an information-hunter She "asks" the reservisor, for example, what time that flight is arriving.

Electronics take over, pick up the latest word, and flash it back to the set. On arrivals, the set tells the agent whether the flight is on time, early, or late, and spells this out in increments of 5 minutes up to a total of 1 hour and 15 minutes.

For departures, the machine informs an agent if the flight is routine or delayed, and the reasons for the delay. For more complicated flight decisions, a "call" button illuminates, directing the agent to call a central position for further word.

As flight information is introduced into the equipment, it is immediately available to all customer service agents in the New York–Newark–Idlewild area. Moments after the facts are known in the dispatcher's office, agents can be quoting concise uniform information.

Detailed Survey Made of High-Altitude Laboratories

By ski, car, bus, aerial cableway, and train scientists throughout the world are climbing mountains to at least 42 high-altitude research laboratories and observatories.

This is disclosed in a report issued recently on the first comprehensive survey of the world's high-altitude research stations. Dr. Serge A. Korff, cosmic-ray physicist at the New York University College of Engineering, New York, N.Y., edited the 100-page volume. The Research Division at the College of Engineering published the study for the Joint Commission on High Altitude Research Stations, an agency of the International Union of Biological Sciences and the International Council of Scientific Unions.

The report describes every known high-altitude research station with the exception of those behind the Iron Curtain. Questionnaires were sent to Soviet Russia, Dr. Korff said, but were never returned.

Cosmic rays, radio astronomy, meteorology, astrophysics, botany, terrestrial magnetism, and solar radiation are a few of the fields which benefit greatly from research at high altitudes.

Although the detailed report covers only active stations, 46 additional potential station sites are listed. These include Mt. Etna in Sicily, Kilimanjaro in Tanganyika, two high passes in Morocco, and several passes, summits, and abandoned mining camps in the western part of the United States.

Engineers Develop Techniques to Save Construction Man-Hours

New methods and equipment are helping Commonwealth Edison Company to wage a winning fight against time and weather as the Chicago, Ill., utility nears the completion of a new 16-mile underground installation of 138,000-volt pipe-type cable.

Utilizing three unsheathed cables in a coated steel pipe, the line is being linked to two of the company's generating stations to supply power principally to important industrial areas of the city. With its 2,000,000-circular-mil conductors, it will have the country's highest load-carrying capacity for 138,000-volt pipe-type cable.

In planning the $5-million project, Edison engineers developed the techniques that are now paying time-saving dividends. To guard against moisture, special reel-hauling trailers with metal enclosures were constructed. Loaded indoors and equipped to be placed in service as soon as they arrive on

IN FLIGHT DISPATCH, operator puts flight information into the reservation machine. By placing the serrated plate in the agent set (left), depressing the key for the flight, a circuit is established to the proper spot for recording on a whirling magnetic drum. Data are put into the machine by the master agent set shown at right of operator and in close-up.

IMPROVED SPLICING methods make it possible for two splicers and two assistants to complete a joint in 60 hours. When work is completed, split-sleeve steel casing is pulled over the cable and welded together in about 8 hours. Three miles of tape, soaked in oil, are used for each joining.

the job, the trailers have reduced weather-caused stoppages to a minimum. They also have eliminated on-the-street use of a crane unloading and setting up reels of cable, which average 13 to 15 tons.

Cable pulling similarly has been simplified by a specially equipped winch truck, which tows a boom and trailer-mounted sheave wheel to the daily scene of operations. Here, too, the mobile units have done away with the need of a crane to unload and place heavy equipment.

More hours are being saved by improved splicing methods which have made it possible for two splicers and two assistants to complete a joint in 60 hours. Splicers learned the faster technique by attending a week's training course.

Edison engineers are confident that the newest link in their high-tension network will prove to be as dependable as its forerunners. Back in 1927, for example, the utility was the first to put high-voltage oil-filled lead-covered cable into commercial service. This was in the world's first underground line to operate at 138,000 volts, which doubled the previous maximum for such lines.

Largest Compressed-Air Breakers Purchased by Consolidated Edison

The Consolidated Edison Company of New York has announced the purchase of 11 138-kv outdoor compressed-air breakers from the Westinghouse Electric Corporation. The breakers will have an interrupting capacity of 10-million kva.

These are the first outdoor compressed-air breakers of this rating to be built for an electrical utility by an American manufacturer. Although the breakers will operate at air pressures of approximately 350 pounds per square inch, they will be practically noiseless in operation. Since they will be applied in highly congested areas, the use of compressed-air breakers is highly preferred over the oil-filled designs previously used.

"Double Major" Course Will Be Given at MIT

Establishment of a new type of "double major" course in which undergraduates at Massachusetts Institute of Technology (MIT) may combine studies in science or engineering with humanities and social sciences has been announced by President James R. Killian, Jr.

For the first time it will be possible for a student to obtain a bachelor of science degree by qualifying in both liberal arts and technological fields. The new plan of study will be open to freshmen entering MIT next fall. It was given final approval by the faculty, without dissent.

Newly Designed Control Uses Printed Circuitry Panels

Printed circuitry and a new simplified control system are features of a new line of full-wave electronic adjustable-speed drives, available at prices approximately 20 per cent lower than previous models of the same type by the General Electric Company. Among the first printed circuitry to be incorporated in industrial control equipment, the print-board panels can be visually inspected for circuit faults since the panels are equivalent to current-carrying diagrams. The panels can be removed and replaced in a few seconds' time.

The new control circuit uses only a single miniature-type control tube, as contrasted with three conventional-sized tubes in previous models, so maintenance on the equipment is simplified. The new design has isolated a-c control circuits that allow interconnection with a-c drives without the use of additional relays. Power tube capacity is at least 40 per cent greater than the full-load current of the motor with which it is used, providing ample margin for overload and assuring longer tube life. The new design is available in two ratings, 3/4 to 1 hp, and 1½ to 3 hp, full wave.

Other drives with conventional circuitry are available in full- or half-wave models in ratings up to 1/2 hp. Full-wave precision models are also available in ratings from 3/4 to 30 hp.

PRINTED CIRCUITRY for simplified control system featured in new line of full-wave electronic adjustable-speed drives.

Television Transmitting Tower Erected Atop Mt. Mansfield, Vt.

Atop the highest point in Vermont, 4,100-foot-high Mt. Mansfield, a television transmitter station has finally brought video to more than a half-million "north country" folk previously blacked out in the mountainous area of upper New England.

WMVT-TV TRANSMITTER station, located on Mt. Mansfield near Burlington, Vt.; has a coverage of 100 square miles.

The station, towering above the famed skiers' paradise of the Mt. Mansfield section, is Vermont's first television station, last state in the nation to have television. It brings video for the first time into homes in portions of four states; northeastern New York, Vermont, New Hampshire, and Maine. It also penetrates into Canada, to a point 50 miles north of Montreal.

Televising on Channel 3, the station *WMVT-TV*, is owned and operated by Mt. Mansfield Television, Inc., Burlington, Vt., 20 air miles away. *WMVT-TV* is a Columbia Broadcasting System primary affiliate.

The 50-foot-high transmitter tower was constructed to withstand high winds up to 150 mph, so it was necessary to anchor the tower solidly to the rock surface of the mountain. On top of the tower a 4-bay antenna was erected, standing 66 feet above the point where the tower ends. The bays are electrically heated in winter time to prevent ice accumulations. The tower is connected by two 3/8-inch copper feed lines to the transmitter housed some 350 feet from the base of the tower.

The station contains General Electric equipment throughout, and employs a 5-kw transmitter, which with the 4-bay antenna obtains an effective radiator power of 18.3 kw. Two Caterpillar diesel-electric sets provide alternate power as needed for the total peak load of 48 kw.

A U. S. Weather Bureau Sub-Station has been established with *WMVT*, and engineers on the mountain make regular daily checks on weather instruments for the Bureau. Instruments include a wind velocity gauge attached to the television tower itself, thermometers, and rain and snow gauges installed at the transmitter building.

Low Bidders and Schedules Are Determined by Computers

Methods which utilize high-speed electronic computers for quickly and accurately determining low bidders on Government contracts have been developed by the National Bureau of Standards (NBS). Now being used by purchasing agencies of the Department of Defense, the NBS methods provide an exact basis for awarding contracts among competing bidders at least cost to the Government. Contracts for several million dollars worth of soap, paper, insignia, and other products have been let on the basis of computations carried out on SEAC (National Bureau of Standards Eastern Automatic Computer), with consequent savings in time and costs.

In general, the analyses required in awarding Goverment contracts are extremely complex. Although each procurement presents its own special difficulties, all have certain features in common. For example, in most cases the Government buys simultaneously for several depots. The different freight costs from the factories to the depots enter significantly into the cost of the item purchased; hence, the manufacturer's bid prices must be modified to indicate the true cost including transportation. Also, each manufacturer generally states a maximum quantity he is willing to produce, and frequently he states a minimum acceptable quantity as well. He may quote several prices, depending on the quantity award. In fact, he may impose any of a wide variety of restrictions and conditions on his bid. The problem faced by the awarding agency is to determine the quantity each manufacturer should make and the depots to which he should ship his production. The computation methods used by the Bureau not only provide an exact answer in a short time but also determine shipping schedules for each manufacturer so that, for example, the right sizes of clothing, properly packaged, reach each depot in the required amounts each month.

SEAC COMPUTING ROOM at the National Bureau of Standards. Control console is at the far end of the room, and to the right are several of the external storage units which store on magnetic tape such information as coded subroutines, instructions to the machine, and numerical data, as well as the entire coded program for a problem.

The high-speed computation methods now being used in determining low bidders have resulted from a continuing program of research which the Bureau is conducting for the Air Force in the mathematical theory of linear programming. This new mathematical field, in combination with electronic computation, provides a speed and accuracy previously unobtainable in the solution of certain military supply and logistics problems.

Radio Direction Finder Is Completely Automatic

Raytheon Manufacturing Company announced recently the development of a new automatic radio direction finder which has proved itself invaluable in assisting marine navigators to determine their exact positions in the offshore waterways.

The Waltham, Mass., electronics firm described the device as the first fully automatic radio direction finder specifically designed for marine use. Designated the *RD-132*, it was developed in co-operation with the U.S. Coast Guard for use in search and rescue missions. Just as an ordinary pocket compass points to magnetic north, the operator may tune in whatever station he desires in the "marine" band and "beacon" band, and the needle on the dial will automatically swing around and point to the station to which the set is tuned.

The tuning range is in two bands: from 275 to 510 kc, and from 2 to $3^{1}/_{2}$ mc. Most of the ship-to-shore radiotelephones operate within the two frequencies covered by the new direction finder, so a vessel equipped with the device can quickly locate a ship in distress simply by receiving its radiotelephone message. Another common use is finding one's position offshore with the help of two radio stations or beacons. By tuning in one station and then the other, the two compass bearings are obtained.

Network Calculator Available to Utilities and Industrial Companies

A new a-c network calculator has been built and put into service by the Westinghouse Electric Corporation at their East Pittsburgh, Pa., plant. The calculator is available to users on a rental basis.

The new calculator is designed to accommodate the largest interconnected systems and power pools that are in existence today. There are a total of 668 circuit components representing generators, transformers, transmission lines, and loads.

A-C NETWORK CALCULATOR is available to utilities and industry on a rental basis.

The newest feature of the calculator is individual load regulation for the 36 generator units. A preset value of watt output can be held on each generator unit, irrespective of the rest of the system. Consequently, electrical utility systems set up in miniature on the calculator can be operated much like their prototypes; a fixed load is set for each generator in the system except the "swing" unit, which is adjusted to take up the slack. This saves many time-consuming adjustments previously required to divide load properly among calculator generators.

All circuit components can be measured from either of two instrument desks. The calculator can be divided into two complete separate units for handling smaller problems. The new calculator replaces an earlier model built in 1942, which replaced a still earlier one installed in 1929.

"Electronic Supervisor" Developed for the Control of Plant Facilities

A new "electronic supervisor" that follows preset programs and automatically switches on or off up to 40 groups of remote operations—each on its own time schedule—was demonstrated recently by the International Business Machines Corporation (IBM).

The new IBM Central Control System

PROGRAM ELECTRONIC supervisor controls office and plant operations will switch lights on or off, start and stop motors, open and close valves, control air conditioning, and perform scores of similar operations. Its most advanced application will be to start and stop production line machinery in automated plants. It is expected to facilitate plant and office automation.

An outstanding feature of the new central control system is that it uses carrier-current signals and operates over existing electric circuits. It does not require the installation of a single transmission wire.

A second important feature is the central operations panel. A plant, department store, or school building superintendent, for instance, can check on his many remote electrically controlled services by merely glancing at the indicator lights on the panel. Such automatic control and supervision permit more economical operation of the machinery and services in a plant by utilizing them only when they are needed. This can result in savings in fuel, water, electric power, and other resources.

The system will go through its operations automatically, maintaining the exact schedule established on its programs. If it is necessary to depart from the preset program, manual operation is possible. A supervisor can break in on the control system at the central panel, say, to turn on facilities for a special night shift; or he can break in at the remote relay, perhaps to turn on the lights or to stop the motors in a particular section of the plant.

The system utilizes commercial 60-cycle power and lighting circuits for the transmission of its supervisory signals. These "command" signals or pulses are superimposed on the existing circuits and in no way interfere with regular electrical functions.

The basic components of the system are its central operations panel, transmitter, and coded relays. The central operations panel is the source of the system's directions or "commands." Through its relays and an electronic transmitter, "command" pulses of audio frequencies are sent to coded relays for operation of electrical services, with the coded relays rejecting all pulses other than those to which they are preset to respond.

MIT Offers Two Special Summer Programs for 1955

To describe the basic role of radar in meteorology and to present some of the newest concepts, a 2-week special summer program on "Weather Radar" will be given by the Massachusetts Institute of Technology (MIT), Cambridge, Mass., from June 14 through June 24, 1955.

The program will be under the direction of Alan C. Bemis, research associate in the Department of Meteorology at MIT, assisted by J. Francis Reintjes, associate professor of electrical engineering and director of the MIT Servomechanisms Laboratory; J. Stewart Marshall, professor of physics at McGill University; and David Atlas, radar meteorologist in the Geophysics Research Directorate, Air Force Cambridge Research Center.

"This special summer program," explains Mr. Bemis, "is designed for the short-range forecaster (particularly in aviation), the researcher in cloud and precipitation physics, the 'rain maker,' and the electronics engineer interested in the design of weather radar systems and associated instruments."

Lectures and laboratory studies will include such areas of radar meteorology as elementary principles of radar, presentation and interpretation of radar data, hurricanes, tornadoes, and other severe storms, and the nature of precipitation echoes and its relation to particle motions. If and when interesting storms are detected on the radar systems, there will be opportunity to observe the various radar techniques in operation.

Although training in meteorology is not a prerequisite, such a background will be of material aid; in particular, a familiarity with the physics of the atmosphere is desirable.

To consider the physical and engineering aspects of high-energy radiations and the techniques of applying them to industrial purposes, another special summer program on "Ionizing Radiations for Industrial Processing" will be offered at MIT, June 20–24, 1955.

Professor Ernest H. Huntress, director of the MIT Summer Session, points out in announcing the program that high-energy particles and other radiations from machine accelerators and radioactive sources are proving of rapidly growing interest to industry.

Dr. John G. Trump, professor of electrical engineering, will direct the program, assisted by Dr. William W. Buechner and Dr. Robert J. Van de Graaff, both associate professors of physics; Kenneth A. Wright, staff member of the MIT High Voltage Research Laboratory; and other MIT staff members and invited guest lecturers.

Discussions, demonstration lectures, and visits to typical radiation sources are planned. Lecture topics will include: high-energy electrons, ions, neutrons, X rays, and gamma rays; interaction of high-energy radiations with matter; dosimetry and protection in radiation processing; energy and economic aspects of irradiation; special applications of radiation in industry and medicine.

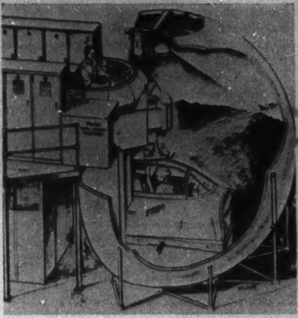
Registrants for these special summer programs may reserve rooms in the institute's dormitories during the program. All MIT recreational facilities, including the swimming pool and the sailing pavilion on the Charles River Basin, will be available for their use.

Full details and application blanks may be obtained from the Summer Session Office, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

Fixed Gunnery Trainer Aids in Teaching Fighter Pilots

The development of a new fixed gunnery trainer, a classroom device for teaching fighter pilots the tactical use of a modern fire control system, was announced recently by the Air Research and Development Command Headquarters, Baltimore, Md.

The new flight simulator, officially designated *F-86D/F-151* Fixed Gunnery Trainer, will improve crew quality by providing supervised training in basic techniques and procedures of air-to-air and air-to-ground gunnery. This will allow in-flight practice to be devoted to perfection of techniques. This trainer was designed and manufactured by Rheem Manufacturing Company of Philadelphia, Pa., in co-operation with Wright Air Development Center, Dayton, Ohio.



FIXED GUNNERY TRAINER provides pilots with training in techniques and procedures.

The trainer consists of a conventional flight simulator, fire control system, spherical screen, a target image projection system, and an instructor's console. It employs a television pickup and projection system to portray a realistic simulation of targets and maintains a continuous true-to-life spacial situation between interceptor and target regardless of course, speed, or type of maneuver. Gunnery controls, flight controls, instruments, and flight characteristics are identical to those in the *F-86* aircraft.

Transonic-Supersonic Tunnel Is Built at Cornell Laboratory

The Cornell Aeronautical Laboratory, Inc., recently announced completion of a new wind tunnel that will permit further fundamental and exploratory research in the transonic and supersonic speed ranges.

Project Engineer John G. Wilder of the laboratory's aerodynamic research department said that although aircraft capable of flight in the transonic and supersonic ranges have been built, many basic problems of airflow and design remain unsolved. This is particularly true in the transonic speed range (700 to 900 mph) where mixed subsonic and supersonic flows exist side by side. The new tunnel is now going through a shakedown period before actual testing is begun. Technically, it is known as a continuous-flow vertical-return variable-density transonic-supersonic wind tunnel. These features permit the engineer to collect data as closely approaching free-flight conditions as is presently possible.

Dimensions of the test section are 1 square foot. The tunnel is 46 feet long and 15 feet high. The tunnel shell, built at the Quaker City Iron Works, Philadelphia, Pa., weighs about 20 tons. Speed range of the new facility will be from Mach number 0.8 (high subsonic) to 2.8 (more than $2^{1}/_{2}$ times the speed of sound).

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Pickups and Accelerometers

To the Editor:

Readers interested in the absolute calibration of pickups and accelerometers by the method described on page 269 of the March 1955 *Electrical Engineering* may find some benefits in the paper, "The Absolute Calibration of a Brush Accelerometer and Its Response to Square Waves of Displacement and Velocity." This appeared in *Transactions*, American Geophysical Union, vol. 31, no. 5, October 1950, pp. 690–5.

PIERRE M. HONNELL

(Washington University, St. Louis, Mo.)

Calculating Electrodynamic Forces

To the Editor:

A letter entitled "Dean Harrington's Omission" by G. B. Kholiavskii appeared in *Elektrichestvo*, April 1954, pages 82–3. The letter referred to my paper, "Forces in Machine End Windings," AIEE *Transactions*, October 1952, pages 849–58. Following my letter is a translation of this letter.

Mr. Kholiavskii's letter makes reference to his paper "Grapho-Analytical Method of Determining Electro-Dynamic Forces in High-Voltage Apparatus," which appeared in *Elektrichestvo*, no. 6, 1950, pages 58–62. I have had his paper translated into English and am prompted to make the following comments:

1. My 1952 AIEE paper did not refer to his 1950 paper. It is easy to understand how he could feel that an injustice had been done, inasmuch as my paper followed his by 2 years. The fact is that I was unaware of his paper until, quite by accident, one of my associates recently noticed a reference to his letter in *Elektrichestvo*.

2. I consider that these two papers, Mr. Kholiavskii's and mine, constitute an interesting example of independent action along parallel paths. It is even possible that the work reported in the Russian paper was being done at the time when R. L. Flower and I were making the study reported in my 1952 paper. Our study was in process during the period between June and November, 1947.

Independent action in two distant countries serves to demonstrate the interest in electromagnetic forces on current-carrying conductors.

3. Mr. Kholiavskii's paper represents general force relations for current-carrying conductors and constitutes an additional reference on the subject. His paper refers to three Russian papers which are listed here for the record.

(*a*) Vestnik Eksperimental'noi u Teoreticheskoi Elektrotekhniki, **V. B. Romanovskii.** no. 5–6, 1931 (in Russian).

(*b*) High-Voltage Engineering and Power Transmission, **A. A. Smurov.** Vol. 3, ONTI, 1935 (book in Russian).

(*c*) The Foundations of Electrical-Machinery Construction, **A. Ia. Builov.** Gosenergoizdat, 1946 (book in Russian).

Inasmuch as no reference was made to any of the four Russian papers in the discussions of my paper in 1952, it seems safe to assume that this letter to you will serve as the first American reference to them.

4. Comparing the two papers, there are areas of overlapping and there are differences in approach. Mr. Kholiavskii's paper dealt with forces between various combinations of straightline conductors. My paper was concerned particularly with the problem of the evaluation of forces on machine end winding conductors.

DEAN HARRINGTON

(General Electric Company, Schenectady, N. Y.)

(*Translation of letter to the editor appearing in "Elektrichestvo", April 1954, pages 82–3.*)

A paper by Dean Harrington entitled "Forces in Machine End Windings" describes a method for calculating electrodynamic forces used in designing the windings of impulse generators for the General Electric Laboratory. Although the author of that paper mentions that the method was developed with the help of other General Electric engineers, it can be readily shown that the main underlying principle of the method is the same as that proposed by me in 1950.

My method is based on the calculation of dimensionless "circuit coefficients" which determine, for a given geometric arrangement, the electrodynamic forces between two sections of conductors carrying current. The entire circuit is replaced by a series of straight segments. The circuit coefficient for two segments are differently arranged (segment acted upon—*1*, acting segment—*2*). They are determined by constructing on segments *1* and *2* a quadrilateral (for parallel segments, a trapezoid), and introducing in the formulas the length of the diagonals (D_1 and D_2) and sides (S_1 and S_2) of these quadrilaterals and nonparallel segments. Also, the projections of these diagonals and sides on the directions of the segments *2* and *1* are introduced. I have shown that in this case most of the formulas of practical importance may be reduced to a few (two or three) universal formulas having a simple structure of the same type.

Thus, for any arrangement of parallel segments, the formula for the circuit coefficient has the following form

$$k_{1/2}=k_{2/1}=\frac{(D_1+D_2)-(S_1+S_2)}{H}$$

where H is the height of the trapezoid (distance between segments).

For any finite segments in one plane which include an angle α the formula (using abbreviated notation) has the form

$$k_{1/2}=\frac{1}{\sin\alpha}\ln\frac{D_1 . D_2^{\pm 2}}{S_1 . S_2}+\frac{1}{tg\alpha}\ln\frac{D_1 . D_2^{\pm 1}}{S_1 . S_2}$$

where the upper-right-hand sign indicates that the length of each diagonal D or side S is supplemented by the length of its projection on the direction of the segment *1* or *2* with a plus or minus sign.

For perpendicular segments, this formula is reduced to

$$k_{1/2}=\ln\frac{D_1 . D_2^{2}}{S_1 . S_2}$$

Harrington's paper repeats without any references in the text or in the bibliography the derivation and formula for parallel finite segments in the same form as given in my paper published in 1950 in *Elektrichestvo.* True, the author does not call the rays diagonals and sides of a quadrilateral and denotes them by letters at random. This, of course, does not change the underlying principles, except that it makes the formulas less clear. For inclined segments, the author gives formulas having the same structure as the above universal formula in my paper, repeating it without derivation several times for different arrangements of the inclined segment.

Attention is called to the extreme similarity between Fig. 8 in Harrington's paper and Fig. 8 of my own paper, although Harrington confines himself to the less general case of a semifinite acting conductor.

The formulas given in Harrington's paper for skewed conductors are of interest, but only of relative importance because they practically give only the projection of forces on a certain plane.

It is also noteworthy that Harrington, in his paper published in 1952, confines himself to a consideration of the total force on the entire segment. He gives no formula for determining the point of application of the resultant of the electrodynamic forces. Apparently, Harrington used only the material published in my paper in 1950 (the content of which he had been able to become acquainted with) since he did not draw the conclusions following from the content of my other paper devoted to the same problem. In the other paper I derived formulas for determining the point of application of the resultant of the electrodynamic forces, as well as general formulas for inclined finite segments.

The absence in Harrington's paper of any reference to the U.S.S.R. literature, where the method of calculation of electrodynamic forces was published more than 2 years previous to the publication of his paper (and in many cases in a more complete and systematic form), is a very regrettable "omission" by Dean Harrington and the editors of AIEE *Transactions.*

G. B. KHOLIAVSKII

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE APPLICATION OF RESULTS OF RESEARCH. Compiled and edited by Vera Connell. Academic Press Inc., 125 East 23rd Street, New York 10, N. Y., 1954. 212 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $5. Originally given as a report to the 1952 British Commonwealth Scientific Conference, this book has been brought up to date for publication. The main text reviews methods used and obstacles to be overcome in putting results of research into practice in industry and agriculture. A statement of principles and recommended procedures is included. Extensive appendixes describe the research institutes of the Commonwealth countries and discuss methods used by each to encourage application of research results.

ATOMIC ENERGY AND ITS APPLICATIONS. By J. M. A. Lenihan. Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y., 1954. 265 pages, $7^{1}/_{2}$ by 5 inches, bound. $4. A simplified account of the fundamentals of nuclear science and its present and potential applications in medicine, science, and industry. Written for specialists in other fields, the book assumes a knowledge of college physics. References for further study are given at the end of each chapter.

CONTROL-SYSTEM DYNAMICS. By Walter R. Evans. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 1954. 282 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7. The analysis of the dynamic response of linear systems is the main theme of this book. Problems of design, typical components, and physical and mathematical concepts involved in control systems are treated, and the La Place transform, frequency-response, root-locus, and other methods of analysis are discussed and applied to a variety of problems. The root-locus method, developed by the author is applied in separate chapters to the solution of multiple loop systems and circuit analysis. The final chapter discusses graphical analysis of nonlinear systems. A brief bibliography is included.

DIELECTRICS AND WAVES. By Arthur R. von Hippel. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1954. 284 pages, $11^{1}/_{4}$ by $8^{3}/_{4}$ inches, bound. $16. In this treatise intended for physicists, chemists, and engineers, dielectrics are identified as any material considered in interaction with electric, magnetic, or electromagnetic fields. The microscopic and molecular approaches form the two parts of the study. Part one introduces complex permittivity and permeability as fundamental parameters, and discusses essential field concepts, propagation of electromagnetic waves, and measuring techniques. Part two deals with the action of induced and permanent electric and magnetic moments from atoms and molecules to the condensed phases, and surveys the formation and behavior of mobile charge carriers.

ELECTROMAGNETIC THEORY. By V. C. A. Ferraro. Athlone Press, London, England, (distributed in U. S. by John de Graff, Inc., 64 West 23rd Street, New York 10, N. Y.) 1954. 555 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $7. This book gives an account of the subject from a mathematical point of view and uses vector methods throughout. The material is presented in three divisions dealing with electrostatics and magnetostatics; solution of boundary value problems; and electrodynamics. Treatment is in sufficient detail to meet the requirements of candidates for a first degree in mathematics.

FIBERGLAS REINFORCED PLASTICS. By Ralph H. Sonneborn and others. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1954. 240 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $4.50. Discusses materials, properties, manufacturing processes, machining and finishing, designing, and applications. A second part consists of two contributed chapters, one a mathematical treatment of design theory, the other a consideration of design from the strength, weight, and economic standpoints. Appendixes provide a glossary and selected bibliography.

ASTM STANDARDS ON COPPER AND COPPER ALLOYS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1954. 584 pages, 9 by 6 inches, paper. $5. This compilation brings together in convenient form 123 standards covering specifications for electrical conductors; plate, sheet, rolled bar, and strip; rod, bar, and shapes; wire; pipe and tube; ingot; sand and die castings; filler metal; and methods of test for copper and copper alloys. Standards are arranged in numeric sequence with a subject index.

ELECTRIC POWER STATIONS, VOLUME I. By R. H. Carr. Chapman and Hall Ltd., London, England, fourth edition, 1954. 605 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 70s. This book deals with general principles governing design, construction, and operation. The major topics discussed are fundamentals of station design, sites and buildings, circulating water systems, cooling towers, coal-handling plant, ash-handling plant, boiler plant, pipework, and turbines. There are chapter bibliographies.

ELECTRIC TRACTION. By A. T. Dover. Sir Isaac Pitman and Sons, Ltd., London (distributed in U. S. by Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y.), third edition, 1954. 441 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $12.50. Covers the distribution and application of electric power to railway trains, streetcars, and trolley buses. Essential principles of mechanics of train movement, traction motors, track construction, overhead construction, and related topics are discussed and illustrated by examples of railway and road vehicles and their equipment.

ELECTROACOUSTICS. (Harvard Monographs in Applied Science, no. 5). By Frederick V. Hunt. Harvard University Press, Cambridge, and John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 260 pages, $8^{1}/_{2}$ by $5^{3}/_{4}$ inches, bound. $6.00. Includes an historical account of electroacoustical transduction, a new method for the analysis of electrostatic and electromagnetic systems of electromechanical coupling, and examples of this method as applied to moving-conductor (dynamic), electrostatic, and moving-armature (magnetic) transducer systems. There are bibliographical footnotes.

INTRODUCTION TO ATOMIC PHYSICS. By Otto Oldenberg. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., second edition, 1954. 421 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.00. A textbook for students with a year of physics and familiar with the elements of chemistry. Emphasizing the relation between theory and observed fact, the book treats the subject under the following broad headings: the structure of matter, gases, structure of electricity, structure of light, electronic structure of atoms nuclear structure, and the wave nature of matter.

INTRODUCTION TO OPTICS. Geometrical and Physical. By John K. Robertson. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y., fourth edition, 1954. 416 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.00. This is an intermediate textbook with a large portion of the text devoted to wave motion and its ramifications in light, but with attention paid to quantum ideas. The revision incorporates discussion of nonreflecting glass surfaces, interference filters, the phase contrast microscope, and other topics, and a chapter on the velocity of light has been added.

LIGHTING FOR COLOR AND FORM. By Rollo Gillespie Williams. Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y., 1954. 340 pages, $9^{1}/_{4}$ by 6 inches, bound. $8.50. A four-part study of the scientific facts concerning light and color, in combination with psychological and emotional values. It deals with basic principles of light, color perception, and illumination control and computation; light sources, color equipment, dimmers and controls; psychological and aesthetic factors; and applications in such fields as architecture, television, advertising, and display.

NUMERICAL ANALYSIS. By D. R. Hartree. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y., 1952. 287 pages, $9^{1}/_{2}$ by $6^{1}/_{4}$ inches, bound. $4.80. A logical treatment of algebraic and analytical processes for getting certain numerical results from certain given data. Skipping the elementary arithmetical operations but avoiding the higher analytical procedures, the book keeps to the middle ground useful to engineers and research workers, methods for checking accuracy of results are provided, and there is a final chapter on organization of calculations for automatic digital calculators.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

EJC General Assembly Proceedings. These are the Proceedings of the General Assembly of Engineers Joint Council (EJC) held at New York's Statler Hotel, January 21, 1955. Included are panel presentations on: nuclear engineering, employment conditions, engineering manpower, and EJC service opportunities; the luncheon address of Dr. Dael Wolfle, director, Commission on Human Resources and Advanced Training, and administrative secretary, American Association for the Advancement of Science, "Competitive Demands for High Grade Manpower;" and the dinner address of Donald A. Quarles, "Engineers and Our National Well Being." Dr. Quarles' address was in the April *Electrical Engineering*. He is Assistant Secretary for Defense, Research and Development. $1.00. Requests with remittances should be addressed to Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

Augmented Networks. A method for increasing output by adding similar sections to the basic L-section network is described in this report from the Naval Research Laboratory. Each added L-section, incorporating integral multiples of the same components used in the original section, is connected across the previous series arm, instead of across the shunt arm as in cascaded networks. To study the characteristics of such augmented networks, experimenters used a resistance-capacitance low-pass as the basic L-section. Its performance is compared graphically to that of the corresponding augmented and doubly augmented networks for sinusoidal, impulse, step, and ramp function input signals. Mathematical derivations are included. 28 pages. $.75. Send to Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Code number of report is PB 111290.

Human Relations and Management; Motion Pictures for Industry. Solutions to many problems in personnel management and supervision may be found in this 240-item bibliography which combines in one pamphlet a classified, descriptive list of audio-visual aids—motion pictures, film strips, and recordings. The booklet is a valuable guide for personnel managers, industrial leaders—everyone who must deal with human relations problems in the conduct of business. Subjects covered by the films are: securing employee co-operation, disciplining, handling grievances, giving instructions, organizing work, creating and maintaining worker interest, selecting personnel, building morale, counseling, and conducting conferences. Descriptions are sufficiently detailed to indicate the best uses of the items, and sources are given from which they may be obtained. 26 pages. $1.00. For a copy of this bibliography send to the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (Commerce Building, Room 6227.) Report code number is PB 111233.

INDUSTRIAL NOTES ....

Merger Planned. Plans for the merger of Daystrom, Inc., and Weston Electrical Instrument Corporation have been announced. The plan is subject to formal approval of the agreement of merger by directors and stockholders of both companies. Terms of the merger call for the issuance of one share of Daystrom stock for each share of Weston. The merger is expected to produce mutual advantages. Daystrom's activities have been increasingly devoted to the electronic and electrical field and the Elizabeth, N. J., firm now has approximately 55 per cent of its sales in electronic and allied equipment. Weston has been a leading manufacturer of electric instruments.

General Electric Notes. The General Electric Company has established an atomic organization for the design, development, manufacture, and marketing of atomic power equipment. Formation of this atomic power equipment department, within the Atomic Products Division, centralizes all company activity devoted to peacetime uses of atomic power. Francis K. McCune, for a time, will head the new department as acting general manager. Components under the department and their heads include: atomic power study, Bruce R. Prentice, manager; industrial atomic products study, Vice-Admiral Willard A. Kitts, III, United States Navy (retired), manager; engineering and operating section, F. K. McCune, acting manager; marketing section, Oswald B. Falls, Jr., manager.

A new multimillion dollar plant is being planned in Tyler, Tex., for the manufacture of home-cooling units. Upon completion of the new plant in the fall of 1956, the company will have three facilities devoted to home-cooling equipment. Several hundred persons will be employed for plant operations, most of whom will be hired in Tyler.

Reeves Elected President. Beauford H. Reeves was elected president and general manager of Rockbestos Products Corporation, New Haven, Conn., at a special meeting of the company's board of directors. He succeeds the late Arthur Gove Newton who died suddenly on March 3, 1955. Mr. Reeves has been vice-president and general manager of Rockbestos since 1936. He has been with Rockbestos since 1923, first joining the wire and cable company as an engineer.

Westinghouse Lamp Division Expands. Work has been started in Fairmont, W. Va., on an expansion and renovation program at the glass works of the Westinghouse Lamp Division plant that will cost more than $250,000 and result in even more steady employment than in the past. The installation and rearrangement of glass-making equipment will enable the company to increase the types of glass manufactured at Fairmont. The manufacture of all glass tubes used in the production of Westinghouse fluorescent lamps are made exclusively at Fairmont, as well as the glass stem and exhaust tubing used in the manufacture of incandescent bulbs.

Minnesota Mining Appointments. Robert V. Holton has been named general manager of the Electrical Products Division, Minnesota Mining and Manufacturing Company. Mr. Holton joined the company in 1943, and became sales manager of electrical tapes in 1948. Since 1953 he has been general sales manager of the division.

Leonard A. Johnson has been named general sales manager of the Electrical Products Division. He has been sales manager of electrical products, maintenance, and construction trades, since 1950.

Dr. Wilfred W. Wetzel has been appointed general manager of the Magnetic Products Division. Since 1948 he has been technical director of the Magnetic Products Division.

New Federal Switchgear Plant. The completion of Federal Pacific Electric Company's plant at Scranton, Pa., for the manufacture of a fully integrated line of low- and high-voltage distribution equipment has been announced. Modern lines of unit substations, low-voltage and metal-clad switchgear, motor control centers, and bus ducts are being manufactured. This plant will also headquarter the Eastern Switchgear Division, under the direction of E. A. Williams.

Automation Division Announced. An Automation Division for design and engineering connected with the manufacture of electromechanical assemblies has been formed by the Radio Condenser Company, Camden 3, N. J. Consisting of design and production specialists representing the various fields of engineering, the new group will: design its own electromechanical assemblies to fit customers' automation programs; and on the basis of such designs, determine how to make the company's production automatic. The new division will be headed by Joseph S. Robb, director of engineering, and Edward J. Penberthy, sales manager.

Design Offices Consolidate. Whitman, Requardt and Associates, consulting engineers of Baltimore, Md., have consolidated all their design offices at one location on the fourth and fifth floors of the Lovola Federal Building at 2 West Preston Street, Baltimore 1. The executive offices remain at 1304 St. Paul Street, Baltimore 2.

(*Continued on page 22A*)

Closely Regulated
D-C Power Source of
Permanent
Stability

For mobile or
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STAVOLT®
POWER
RECTIFIERS

- Greatly simplified circuit with fast responding magnetic control of highest reliability.
- No warm-up time, no hunting or drifting.
- Lighter weight, more compact, rugged and field proven. Encapsulated components.
- 11 standard models up to 1500 amps. Meets Spec. MIL-E-7894.

Write for interesting information on STAVOLT rectifiers.

McCOLPIN-CHRISTIE CORP.
3410 W. 67th Street, Los Angeles 43, California
Specialists in Rectifier Manufacturing for 26 Years

Metal-clad switchgear. Horizontal drawout air circuit breakers in rigid, all-welded enclosures. Available in ratings from 2400 v through 15 kv—50 through 500 mva interrupting and 2000 amp continuous.

NEW CONSTRUCTION ECONOMY TIP:

Isolated phase, metal-enclosed bus. For power generating stations. Available in ratings through 69 kv and 10,000 amp.

Nonsegregated phase, metal-enclosed bus. For switchgear connections. Available in ratings 600 v through 6000 amp; 5, 7.5 or 15 kv through 5000 amp.

Unit substations. I-T-E primary and secondary unit substations can be supplied for any application—indoor and outdoor—and in any standard rating.

Low voltage switchgear. For circuit protection. Commercial buildings, manufacturing plants, generating stations. Ratings through 600 v a-c, 250 v d-c, 6000 amp continuous, 15,000 through 150,000 amp interrupting.

BUY AN I-T-E "POWER PACKAGE"

Coordinated engineering, delivery and installation means a better investment

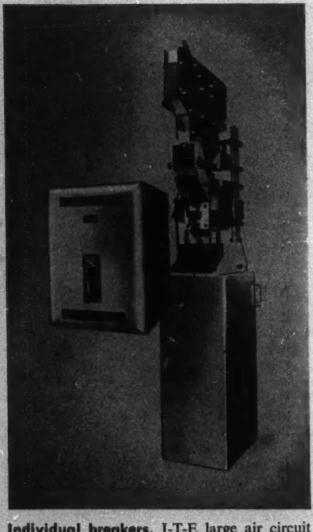
An I-T-E "power package" includes the complete power handling facilities you need for a new construction project, building addition, or simple expansion of electrical service—one unit or a complete system for every application from generation to end use. You save many ways:

Sound planning. Talk with your local I-T-E application engineer about your general power requirements before you build. He'll work with you to determine the equipment needed to assure complete protection with greatest economy in total investment, operating costs, and construction time.

Easier installation. Before you begin construction, I-T-E will supply you with arrangement and channel base drawings. Equipment is factory assembled, tested and ready to install. Standardized frames and panel elements assure that future additions to your switchboard will match and line up.

Coordinated delivery. Shipments are made from I-T-E according to a predetermined schedule. Each part of the complete "power package" is delivered to the job when needed. This saves delays and eliminates inconveniences.

Assured performance. Since I-T-E will supply all equipment—pre-engineered—you are saved the work of coordinating equipment of different manufacture. You can be sure that the separate parts of an I-T-E "power package" will fit and function together.



Individual breakers. I-T-E large air circuit breakers are available in a wide range of types and ratings, 600 v a-c, 250 v d-c, 750 v d-c.

For details, contact the I-T-E sales office nearest you—look in your classified directory under "Electric Equipment." I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Phila. 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY
Switchgear Division

I-T-E

An earnest
electronics engineer
kept worrying
'bout gains non-linear.

• •

Unmeasurable
phase angles
kept him in tangles
And threatened to
wreck his career . . .

Tsk, tsk—too bad he didn't know about

SERVOscope®

Only SERVOscope gives you these 4 features in one piece of equipment:

1. Applicable to both AC carrier and DC servo systems.
2. Built-in electronic sweep, phaseable with respect to generated signals.
3. Comes in 4 models offering frequency ranges from 0.0001 to 60 cps.
4. Generates 3 types of signals:

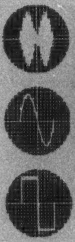
Sine wave modulated carrier.

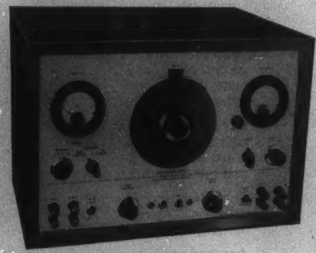
Low frequency sine waves.

Low frequency square waves.

No need to beat around the breadboard . . . SERVOscope speedily and accurately measures gain and phase shifts of L-F amplifiers, servo mechanisms, recorders and other circuits in the subsonic frequency ranges. It takes just a few flicks of the dial to get the values for plotting magnitude and phase curves.

Whether you're developing designs, or production testing—SERVOscope will save you man hours and prevent costly errors.





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(*Continued from page 19A*)

New Plant. The Babcock and Wilcox Company plans construction of a plant for the manufacture of fuel elements and other reactor core components for the nuclear power industry. The plant, to be located about 5 miles east of Lynchburg, Va., is expected to be completed by the end of the year. Making complete nuclear steam generators for the production of electric power is anticipated.

New Laboratory Opened. New England's role as a center for electronic sciences was an invitation to the Radio Corporation of America to establish its Aviation Systems Engineering Laboratory in Waltham, Mass. The laboratory will develop specialized electronic fire-control systems for military aircraft. It is expected to employ by the end of the year, approximately 100 scientists, engineers, and laboratory personnel. Manager of the new installation is Dr. Robert C. Seamans, Jr.

Burton Plans to Expand. Celebrating its 28th anniversary, Burton Manufacturing Company recently broke ground for its 37,000-square-foot plant in Santa Monica, Calif. It will contain, in addition to the company's executive and home offices, a modern machine shop for the manufacture of precision inspection facilities and an electrical and testing laboratory.

Panellit Acquires Jordan Electronic. Jordan Electronic Manufacturing Company, Inc., of Pasadena, Calif., has been acquired by Panellit, Inc. Panellit is engaged in the manufacture of modern automatic control and data-reduction information systems. Panellit plans to accelerate research and development activities of Jordan in the field of industrial measurements in addition to its activities in the nuclear field. Jordan Electronics will operate as a wholly owned subsidiary of Panellit with M. J. Nathason, former owner, as president, and Albert Sperry as chairman of the board. It will occupy, jointly with Panellit's western division, a manufacturing plant to be built in Alhambra, Calif.

NEW PRODUCTS • •

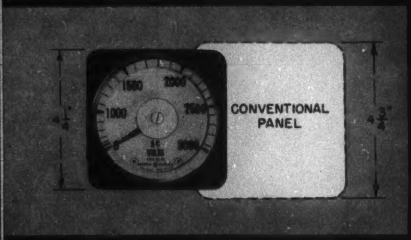
Comparison Bridge. Southwestern Industrial Electronics Company, 2831 Post Oak Road, Houston, Tex., announces a new model of its comparison bridge, to be designated the *E-2*. The instrument can now be operated by means of an optional foot switch, as well as by the conventional push button. Improved stability, accuracy, and sensitivity enable resistors, capacitors, and inductors to be compared over a range of 1 ohm to 5 megohms at 60 cycles. Differences as small as 0.1 per cent may be

(*Continued on Page 28A*)

Make Panel Space Pay its Way

G-E small-size instruments fit 25 to a 24-inch square

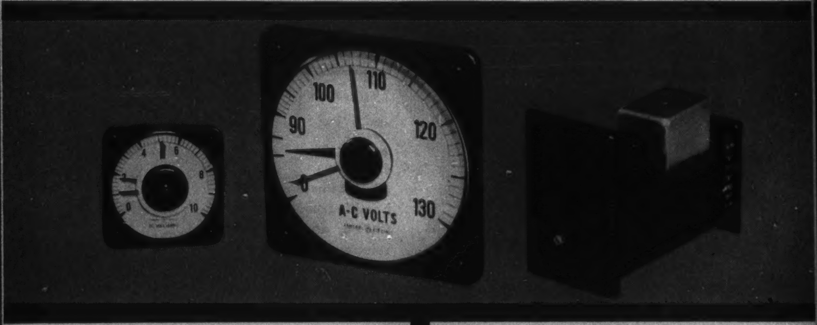
POWER FACTOR
A-C VOLTS
DEGREES C
A-C AMPERES
D-C VOLTS
22
23
24



½-IN. SMALLER than conventional makes, General Electric's 4¼-in. miniature permits economical use of panel space. You can mount twenty-five on a 24-in. square.

TELESCOPIC READABILITY is an inherent feature of the larger 8¾-in. instrument—ideal for locations where convenience dictates taking readings at extra-long distances.

NEW FEATURE INITIATES CONTROL



NEW CONTROL INITIATION for G-E switchboard and panel instruments provides a simple, reliable means to automatize your operations. This contactless all-electrical unit, using industry-tested components, automatically initiates action whenever the instrument indicates a predetermined value. Available on new instruments, the feature can also be added to instruments in service.

For further details, contact your nearest G-E Apparatus Sales representative, or send the coupon shown at the right for a copy of Bulletin GEA-6325.

SECTION D602-289
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, NEW YORK

Please send me your bulletins:

☐ AB-DB 18 and 16 long-scale switchboard instruments (GEC-218)
☐ Control initiation for instruments (GEA-6325)

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City__________Zone____State________

GENERAL ELECTRIC

RAYTHEON

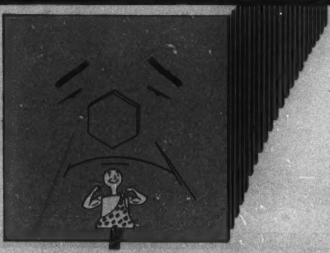
SILICON POWER
to 175°C to 15 amps.
RECTIFIERS
to 200 volts

ACTUAL SIZE

$\frac{R_{REVERSE}}{R_{FORWARD}} > 100{,}000$

Circuit	Number of CK776	Watts Output at Case Temperature† of 30°C	70°C	170°C
One Phase				
Half Wave	1	700	530	265
Full Wave	2	1600	1070	530
Bridge	4	3050	2040	1020
Three Phase				
Half Wave	3	3200	2150	1070
Bridge	6	6800	4550	2270

† Maintained with heat radiator



At maximum power handling capability of CK776, an equivalent selenium rectifier could occupy as much as 100 times the volume.

RAYTHEON SILICON POWER RECTIFIER CHARACTERISTICS

	Maximum Voltage RMS Volts	Maximum Voltage Peak Volts	Maximum Current Peak Amperes	Maximum Current Average Amperes	Typical Dissipation Watts
TYPE CK775					
Case Temp. 30°C*	40	60	50	15	40
Case Temp. 170°C*	40	60	15	5	10
No Heat Radiator					
Ambient Temp. 25°C	40	60	6	2.0	3.0
Ambient Temp. 170°C	40	60	2.0	0.5	2.0
TYPE CK776					
Case Temp. 30°C*	125	200	50	15	40
Case Temp. 170°C*	125	200	15	5	10
No Heat Radiator					
Ambient Temp. 25°C	125	200	6	2.0	3.0
Ambient Temp. 170°C	125	200	2.0	0.5	2.0

*maintained by external heat radiator

At 25°C both CK775 and CK776 have maximum drop at 5 amperes of 1.5 volts.

Maximum reverse current is 25mA for CK775 at −60 volts, CK776 at −200 volts.

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Excellence in Electronics
RAYTHEON MANUFACTURING CO.

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(*Continued from page 22A*)

measured on the 1-per-cent full-scale meter range; other scale ranges of 2.5, 5, 10, and 25 per cent are also provided.

Pressure Bleeder Device. A small compact device for relieving both over-pressure and under-pressure in oil-insulated sealed transformers was recently developed by the General Electric Company and is now being applied on power transformers made in the company's Pittsfield, Mass., and Rome, Ga., plants. The device, called a pressure vacuum "bleeder," is small enough to be held in the palm of a man's hand. It replaces an assembly that was formerly enclosed in a cabinet mounted on the side of the transformer. The new device, which includes provision for attaching a standard gas-sampling valve, can be mounted at any convenient point, and does not require a tube leading from the transformer tank. A vacuum of 0 to −8 pounds per square inch gauge and a positive pressure from 0 to +8 pounds per square inch gauge is the range of actuating conditions that can be selected on the device.

Distribution Panelboards. Plug-in fusible distribution panelboards, *QMB* Saflex, are being marketed featuring quick-make, quick-break characteristics. An outstanding advantage of this new line is its availability. Standardized plug-in components can be stocked by local distributors for immediate delivery on any job requirement. Factory-assembled panelboards are available with 200- to 1,200-ampere mains and may be obtained with or without cabinet door. For further information, write Square D Company, 6060 Rivard Street, Detroit 11, Mich. Ask for *QMB* Saflex Bulletin *SD-29*.

Time Delay Relay. With a new time delay relay currently being marketed by the Automatic Switch Company of Orange, N. J., any delay from 1/2 to 6 seconds may be obtained for all standard alternating voltages (120, 240, 460, 600 volts, 60 cycles). This relay is also available for other frequencies, and for direct current. This new relay is particularly important because of its capacity for handling motor loads directly.

Potentiometers. Eight different models have been announced in the new General Radio *970* series of wire-wound potentiometers. Power ratings range from 2 to 20 watts at 40 C ambient, and 17 stock resistance values cover the range from 2 to 500,000 ohms. All models are totally enclosed, yet capacitance is kept low by the use of phenolic body and cover plus a glass-reinforced-polyester shaft.

Multichannel Waveform Monitor. A new multichannel waveform monitor, which enables a television broadcast engineer to see four video signals simultaneously on a single multigun cathode-ray tube, has been developed by Allen B. Du Mont Laboratories, Inc. The new monitor will be of particular benefit to engineers of sta-

(*Continued on page 30A*)

KEPCO

KR SERIES

7 NEW

VOLTAGE REGULATED POWER SUPPLIES

for powering electronic equipment

SAVE TIME AND MONEY

Build these compact Power Supplies into your equipment!

Kepco Voltage Regulated Power Supplies are conservatively rated and are designed for continuous duty at 50°C ambient. The regulation specified for each unit is available throughout its output voltage range for line voltage variations from 105-125 volts and load variations from 0 to full load.

FEATURES:

- Superior Regulation.
- Ultra-Stable 85A2/OG3 Reference Tube.
- Low Ripple.
- Low Output Impedance.
- Fast Recovery Time, Suitable for Square Wave Pulsed Loading.
- Voltage Range continuously variable without Switching.
- Either Positive or Negative may be Grounded.
- Oil Filled Condensers.
- Wire Harness and Resistor Board Construction.
- Power Requirements 105-125 volts, 50-60 cycles. Units operate up to 400 cycles.
- Terminations and locking type voltage control on rear of unit.
- AC, DC Switches, Fuses, and Pilot Lights on Front Panel.
- Color Grey Hammertone.
- Guarantee One Year.

To include 3" Current and Voltage Meters, Add M to Model number (e.g. KR 1-M) and Add $30.00 to the Price.
To include Dust Cover and Handles for Table Mounting, Add C to Model number (e.g. KR1-C) and Add $10.00 to the Price.
To include Meters, Dust Cover and Handles, Add MC to Model number (e.g. KR-1MC) and Add $40.00 to the Price.
PRICES F.O.B. Flushing.

KEPCO LABORATORIES

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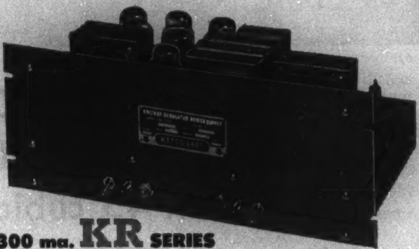
INDEPENDENCE 1-7000

125 ma. KR SERIES

MODEL	OUTPUT	VOLTS	CURRENT	REGULATION		RIPPLE (RMS)	19" Rack Mount		
				line 105-125V.	load 0-max.		W	H	D
KR1 $80.	1 2	100-200 6.3 AC	0-125 ma. 3 amp.	0.3 volts *	0.3 volts *	3 mv.	19"	7"	7½"
KR2 $80.	1 2	200-325 6.3 AC	0-125 ma. 3 amp.	0.2 volts *	0.2 volts *	3 mv.	19"	7"	7½"

*AC Voltages unregulated.



300 ma. KR SERIES

MODEL	OUTPUT	VOLTS	CURRENT	REGULATION		RIPPLE (RMS)	19" Rack Mount		
				line 105-125V.	load 0-max.		W	H	D
KR3 $180.	1 2 3	100-200 6.3AC 6.3AC	0-300 ma. 5 amp. 5 amp.	0.3 volts * *	0.3 volts * *	3 mv.	19"	7"	11"
KR4 $180.	1 2 3	200-325 6.3AC 6.3AC	0-300 ma. 5 amp. 5 amp.	0.2 volts * *	0.2 volts * *	3 mv.	19"	7"	11"

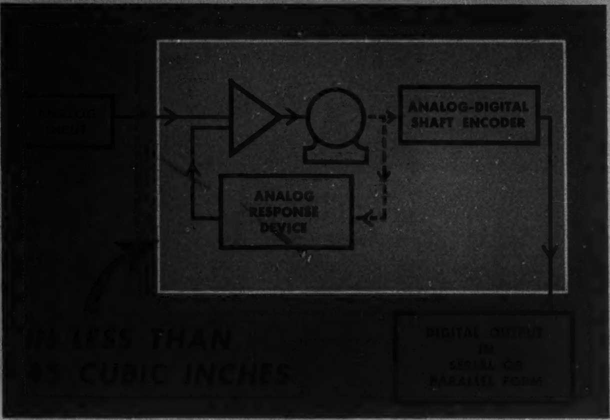
*AC Voltages unregulated.

600 ma. KR SERIES

MODEL	OUTPUT	VOLTS	CURRENT	REGULATION		RIPPLE (RMS)	19" Rack Mount		
				line 105-125V.	load 0-max.		W	H	D
KR5 $240.	1 2 3	100-200 6.3 AC 6.3 AC	0-600 ma. 10 amp. 10 amp.	0.3 volts * *	0.3 volts * *	5 mv.	19"	10½"	13"
KR6 $240.	1 2 3	195-305 6.3 AC 6.3 AC	0-600 ma. 10 amp. 10 amp.	0.2 volts * *	0.2 volts * *	5 mv.	19"	10½"	13"
KR7 $250.	1 2 3	295-405 6.3 AC 6.3 AC	0-600 ma. 10 amp. 10 amp.	0.2 volts * *	0.2 volts * *	5 mv.	19"	10½"	13"

*AC Voltages unregulated.

SINCE 1915 LEADERS IN AUTOMATIC CONTROL


ANALOG INPUT
ANALOG-DIGITAL SHAFT ENCODER
ANALOG RESPONSE DEVICE
DIGITAL OUTPUT IN SERIAL OR PARALLEL FORM
IN LESS THAN
45 CUBIC INCHES

ANALOG TO DIGITAL CONVERSION

in less than 45 cubic inches

In an aircraft navigational system, input information (such as compass headings, speeds, etc.) is received in analogs. The Ford Instrument Company engineers recently had a problem which required the presentation of this information in digital forms. Along with this was the physical problem of weight and size minimization. An Analog-Digital converter was developed which solved the problem. This unit occupied less than 45 cubic inches and required only line voltage with no special power supply.

This is typical of the way Ford Instrument engineers solve problems in the computing and control field. For forty years Ford has been pioneering techniques in servomechanisms; developing, designing and manufacturing systems and components to solve the complex problems of automatic control. Should you have a problem in control engineering it will pay you to talk to one of the Ford Instrument Company engineers.

56

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

(*Continued from page 28A*)

tions originating color programs, because it will monitor simultaneously three color signals—red, green, and blue—and the encoded output of one color channel. In a station not originating color, it will monitor the four outputs of a monochrome multiscanner. Both input and output of an encoder may be monitored simultaneously. Full specifications on the Du Mont Type *TA-202-A* multichannel waveform monitor are available to engineers, broadcasters, and consultants by writing to the Television Transmitter Department, Allen B. Du Mont Laboratories, Inc., 1500 Main Avenue, Clifton, N. J.

Direction Finder. An automatic direction finder which operates on the vhf band (118–148 mc) has been announced by Olympic Radio and Television, Inc. This device obtains useful bearings from an aircraft's vhf transmitter, even when the voice transmission is unintelligible—a signal-to-noise ratio of −20 db. The system consists of a receiver-indicator, a 4-dipole antenna mounted on a mast, and the necessary cables. Designed for airport installation, this low-cost unit has an overall accuracy of slightly lower than 1 degree in the readings obtainable from the indicator. The system sensitivity is 15 microvolts per meter.

Xenon-Filled Tubes. Electrons, Inc., Newark, N. J., has announced production of two Xenon-filled thyratrons having identical electrical characteristics. The *EL C4J* is designed for socket mounting; and the *EL C4J/F* for panel mounting, wherever conventional sockets might not be desirable. Ratings for both types are 4 amperes d-c continuous average anode current; 30 amperes oscillograph peak current with maximum peak forward, and peak inverse of 900 volts. The average arc drop is 12 volts and heating time is 60 seconds. More detailed characteristics, on data sheet forms, can be obtained from Electrons, Inc., 127 Sussex Avenue, Newark 3, N. J.

Miniaturized High-Insertion Loss Filters. A complete series of small high-insertion loss filters for aviation and mobile electric and electronic equipment has been announced by the Sprague Electric Company. The new miniaturized bulkhead-mounting interference filters are available in production quantities in ratings from 0.1 ampere to 20 amperes, for both 125-volt d-c and 125-volt a-c 400-cycle service. The units meet all pertinent MIL and AN requirements for operation at operating temperatures from −55 C to +85 C. Complete performance and engineering data for these filters are available on letterhead request to the Technical Literature Section, Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

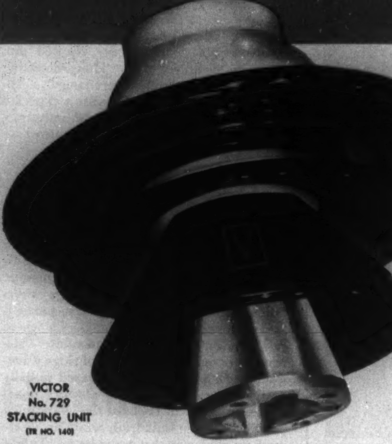
Radiation Detector. A new lightweight portable probe which selectively detects

(*Continued on page 36A*)

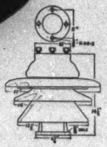
No Finer Apparatus Insulator!

It's VICTOR . . .

made of Purified Porcelain . . .



VICTOR
No. 729
STACKING UNIT
(TR NO. 140)



With VICTOR "Know-How"

Correct design, quality-controlled manufacture, accurate jig assembly and *Purified* Porcelain make VICTOR Apparatus Insulators supreme in their field. These insulators give power men complete assurance because they combine maximum dielectric and mechanical strength. Each VICTOR Apparatus Insulator is individually tested at every point of manufacture. Each has to be precision-perfect before it is shipped. That's why these units are easier to install singly or in stacks, why they stand up better in service . . . why more and more power men are specifying VICTOR.

FEATURES

1. **MAXIMUM MECHANICAL STRENGTH** guarantees on-the-job dependability.
2. **PRECISION ASSEMBLY** assures perfect alignment . . . greatest possible stacking ease.
3. **MADE OF *PURIFIED* PORCELAIN** each insulator has unequaled uniformity of mechanical and electrical values, and resistance to thermal variations.
4. **THICK, RUGGED CORRUGATIONS** afford maximum resistance to impact . . . cut breakage costs.
5. **SCIENTIFICALLY COMPOUNDED CEMENT** assures high bond strength at all assembly joints.
6. **CAPS AND BASES** are hot-dipped galvanized for maximum resistance to weathering and corrosion . . . are engineered to exceed NEMA specifications.
7. **SMOOTH, HARD GLAZE** assists self-cleaning process, reduces maintenance and replacement costs.
8. **RESILIENT COATINGS** at all cemented joints give maximum resistance to thermal variations and mechanical shocks or impact.

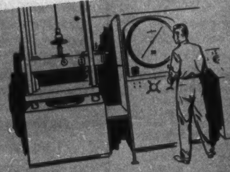
SPECIFICATIONS (SINGLE UNIT)

60 cycle dry flashover	160 KV
60 cycle wet flashover	95 KV
Pos. impulse flashover*	235 KV
Neg. impulse flashover*	290 KV
Withstand voltage 60 cycle dry	115 KV
Withstand voltage 60 cycle wet	75 KV
Withstand impulse voltage*	210 KV
Puncture	215 KV
Dry arcing distance	14¾"
Leakage distance	33"
Tension strength	20,000 lbs.
Torsion strength	40,000 lbs.
Compression strength	60,000 lbs.
Cantilever strength base mtd.	7000 lbs.
Cantilever strength cap mtd.	4000 lbs.
RNI	100 microvolts
1000 KC at applied	22 KV

*Crest KV. 1½ x 40 microsecond wave critical value.

For the full facts on Victor "Know-How," write for "The Story of Victor and Purified Porcelain." For engineering data on Victor Insulators, write for Bulletin No. 4.

NEWS FROM VICTOR



To take care of expanded test facilities, the Victor high voltage laboratory has been greatly enlarged and a new 120,000 pound Tinius-Olsen hydraulic testing machine (shown in drawing above) installed. This machine exerts a programmed load on a test piece while subjected to high voltage current. Tests are run to destruction either by mechanical or electrical failure.

SPECIFY VICTOR

Purified Porcelain

Pintypes

VICTOR INSULATORS DIVISION
I-T-E CIRCUIT BREAKER CO.
VICTOR, N. Y.

Low and High Voltage Pintypes • Suspensions • Guy Strains
Spools • Switch and Bus Insulators • Custom Designed Porcelain
Insulator Hardware

HYSOL 6000
goes to sea with RAYTHEON RADAR

The S. S. Lurline, one of the largest U. S. passenger liners, is the first big ship in the world to install Raytheon's new Model 1500 small boat radar. Scheduled for use as "standby" equipment, it will be used in conjunction with the regular 16-inch big ship "Mariners' Pathfinder" radar, shown in foreground and demonstrating comparative size. Chief Officer R. McKenzie inspects scope reading of the Model 1500.

HYSOL 6000 Epoxide Resins Used in Component Parts . . .

Complicated internal component parts of Raytheon radar equipment are formulated from HYSOL 6000 Series epoxide compounds because of their outstanding electrical and mechanical properties. In addition, HYSOL 6000 Series compounds provide a material which is economically molded into intricate shapes, including complicated inserts.

HYSOL 6000 Series compounds are made from the new epoxide resins and include a complete selection of room temperature and heat curing potting and casting compounds, easily machined sheets, rods and tubes, and coating and laminating varnishes.

PROGRESSIVE PRODUCTS HYSOL Product of HOUGHTON LABORATORIES, INC. THRU CHEMICAL RESEARCH

The Raytheon application of HYSOL 6000 may suggest to you other plastic uses now posing a problem in your design or production departments. Houghton Laboratories, Inc., is ready to assist you with these problems through the experienced services of our skilled research laboratory, design and production departments. Your investigation will be welcomed at no obligation. Write, wire or phone today!

houghton laboratories, inc.

105 BUSH STREET, OLEAN, NEW YORK

(*Continued from page 30A*)

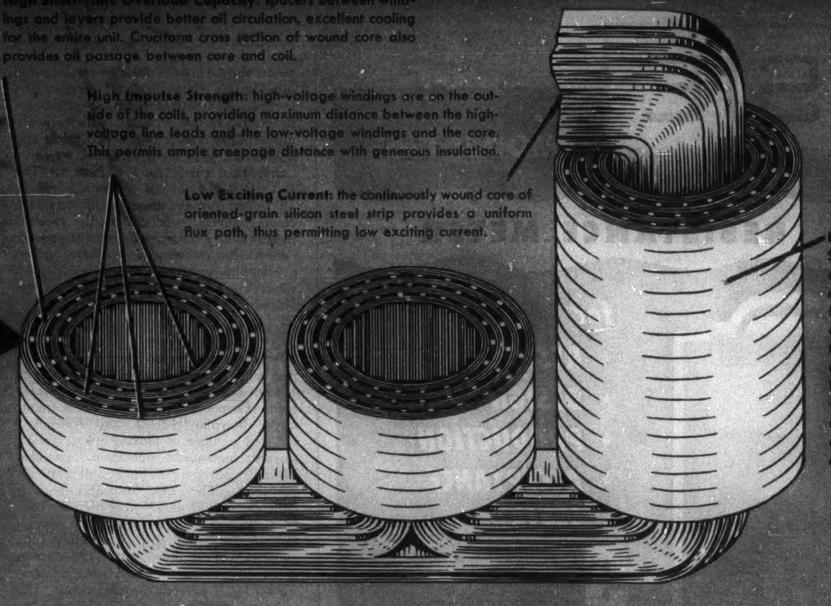
alpha-beta-gamma and thermal-neutron radiation has been developed by the General Electric Company's instrument department. The new device features interchangeable heads for detecting different radiations, extremely high thermal neutron counting efficiency, and the ability to count alpha particles in the presence of high beta-gamma background. In the portable radiation probe, scintillation caused by radiations is detected by a *5819* photomultiplier tube. The output is fed to a high-stability cathode follower preamplifier which operates directly into almost any scaler. A standard connector at the rear of the probe allows connecting cable to be attached to the probe. The phosphors for detecting alpha, beta, gamma, and neutron radiations are incorporated into specially designed caps. These detecting heads can be quickly interchanged. Application of the new instrument is expected to be found in industrial and university laboratories, and hospitals now working with radioactive materials.

Bulkhead Assembly. A ridge waveguide bulkhead assembly for use with C-band or X-band commercial air-borne weather penetration radar has been developed by Airtron, Inc. The new bulkhead assembly permits passage of a run of ridge waveguide through aircraft bulkheads, particularly through pressurized bulkheads where no leakage of air is permissible. The assembly consists of a section of ridge waveguide with a circular plate brazed radially to its center. A retaining plate of equal diameter is used to bolt the waveguide plate fast to the bulkhead, while an intermediate rubber gasket provides an airtight seal. Vibration-proof stop nuts insure air tightness under all conditions of operation of the aircraft. For additional information write for Catalogue *2040*, Airtron, Inc., Department A, 1103 West Elizabeth Avenue, Linden, N. J.

Welding Cable. A fluted welding cable which is long wearing on all types of welding equipment, and has great impact resistance, has been developed by United States Rubber Company. The new cable, called United States Royal Gold Welding Cable, is light and flexible. The unique fluted jacket gives better grip and is cooler to handle, since its greater surface area dissipates heat faster. According to tests conducted by the rubber company, cable flexibility means fewer failures at terminal connections and fewer maintenance and replacement costs.

Modified Version of Dot-Bar Generator. The Tube Division, Radio Corporation of America, has announced a modified version of its *WR-36A* dot-bar generator which can be used for making convergence adjustments in both small-screen and large-screen home color-television receivers. The new version will carry the same *WR-36A* type number. Owners of the first instru-

(*Continued on page 42A*)



High Short-Time Overload Capacity: spacers between windings and layers provide better oil circulation, excellent cooling for the entire unit. Cruciform cross section of wound core also provides oil passage between core and coil.

High Impulse Strength: high-voltage windings are on the outside of the coils, providing maximum distance between the high-voltage line leads and the low-voltage windings and the core. This permits ample creepage distance with generous insulation.

Low Exciting Current: the continuously wound core of oriented-grain silicon steel strip provides a uniform flux path, thus permitting low exciting current.

High Short-Circuit Strength: round coils naturally resist radial short-circuit forces without damage or distortion. Sturdy core clamps and strong blocking aid in preventing axial movement of the windings under short-circuit conditions.

L-M's Uni-Wound® Is Smaller, Lighter, Highly Efficient 3-Phase Transformer

Provides advantages of L-M Round-Wound® core construction in 3-phase transformers in sizes from 112½ through 500 kva. They're lighter, smaller, have improved overload capacity, high impulse level, high short-circuit strength.

By **ALVIN B. COYLE**
Product Manager,
Transformers
Line Material Company

L-M Round-Wound construction consists of a continuously wound core, with round coils wound directly onto the core. This design has a number of advantages in improved performance and better mechanical strength.

Uni-Wound Fills Need

Now L-M engineers have developed a 3-phase transformer with all the advantages of Round-Wound construction. This is the new *Uni-Wound* transformer, which is now in production in sizes from 112½ through 500 kva, and in voltages through 13,800. In smaller 3-phase sizes L-M offers the new *Tri-Wound* transformer.

Continuously Wound Core

The Uni-Wound transformer consists of a unitary core, continuously wound of oriented-grain silicon steel strip. The bare core is annealed after winding. Then round coils are wound directly onto the three core legs by L-M's exclusive winding process.

All Other Round-Wound Advantages

Thus all of the inherent characteristics of the single-phase Round-Wound transformer are provided in the 3-phase Uni-Wound. These advantages include:

high short-time overload capacity
uniformly high impulse strength
high short-circuit strength
low exciting current
lighter weight • smaller size

Uni-Wound Lighter, Lower

The 500 kva Uni-Wound is about 1200 pounds lighter than the stacked lamination type. The 112½ kva, 2400 volt delta Uni-Wound is about 400 pounds lighter than the 112½ kva Triplex style. These lighter weights permit single-pole mounting of sizes through 150 kva instead of the 2-pole platform construction previously required. In some sizes, the over-all height has been reduced as much as two feet, with but little increase in projected floor space.

Balanced Performance

Both the physical and performance characteristics have been well balanced in the Uni-Wound 3-phase transformer design. Just as with the single-phase Round-Wound, no one characteristic has been emphasized at the expense of another. No one characteristic has been considered exclusively by itself, but only in its relationship to the over-all performance of the transformer.

Get Details on Uni-Wound Transformers

Ask the L-M Field Engineer to give you full details; or write Line Material Company, Transformer Division, Zanesville, Ohio. (Line Material Company is a McGraw Electric Company Division.)

194 A-R

LINE MATERIAL Transformers

SIE

MODEL C-6

RESISTANCE METER

for

- RESEARCH
- DESIGN
- PRODUCTION
- ACCEPTANCE TESTS

3

UNIQUE FEATURES

enable the C-6 to meet all requirements

1. Three test voltages:
   1½ volts — for low resistance ranges
   50 volts — for low-voltage capacitor leakage measurements
   500 volts — to meet MIL specs on insulation tests
2. Complete coverage, from zero ohms to 10,000,000 megohms, without auxiliary equipment.
3. Pre-settable "Charge Adjust" control and "Quick Charge" button for rapid Go, No-Go capacitor leakage tests.

ACCURATE • VERSATILE • RELIABLE •

available from stock

$200. f.o.b. Houston

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

P. O. Box 13058
2831 Post Oak Rd.
Houston, Texas

SEND FOR FREE LITERATURE

REPRESENTATIVES THROUGHOUT THE WORLD

5-4-2

(*Continued from page 36A*)

ments will be provided with a special kit of modification parts needed for converting these dot-bar generators for use with large-screen receivers. The kits will be available without charge to service dealers and technicians who have returned warranty registration cards to the factory. The RCA *WR-36A* dot-bar generator, used for all convergence and linearity adjustments in color receivers, produces on the receiver picture tube a pattern of white rectangular dots when convergence is accurate, and an overlapping pattern of red-green-blue dots when convergence adjustments are required.

Bowmar Introduces New Counter. A new angle counter, model *1502*, has been placed in production by Bowmar Instrument Corporation. The unit is made under Bowmar patents, and features a reduced number of moving parts, aiming toward high-speed operation, extended life under adverse conditions, and relatively low cost. The *1502* indicates angular changes from 0 to 359 degrees and back to 0, in 1-degree divisions. One revolution of the input shaft is equal to one revolution of the unit drum. The counter is equally useful in clockwise, counterclockwise, or reversible applications. Descriptive catalogue pages, and pricing schedules, are available from Bowmar Instrument Corporation, 2422 Pennsylvania Street, Fort Wayne, Ind.

A-F Filter. Allison's model *2-A* filter set is engineered for extreme low-frequency applications ranging from 15 to 10,000 cycles per second. The passive network unit, which eliminates vacuum tubes and power supply, has been designed to fill a need for a continuously variable high-pass and low-pass a-f filter. The equipment only has two controls for each group of filters. One control is a switch in octave steps, while the second control is a multiplier, making the filter continuously variable between the octave steps on the switch. High attenuation outside of the passband of 30 db per octave is adequate for most uses. The filter will handle 5 watts in a 600-ohm circuit. Loss in the passband is approximately 1 db, making amplification to compensate for loss unnecessary. Allison's model *2-B* filter covers a frequency range of from 60 to 20,000 cycles per second, offering a wider range at somewhat higher frequencies. Complete technical data and performance curves are available on request from Allison Laboratories, 14185 Skyline Drive, Puente, Calif.

New Directional Gyroscope. A rugged new directional gyroscope has been developed by Gyromechanisms, Inc., Halesite, N. Y., for use in aircraft and missiles. The new unit model *45,000* features a normal Scorsby test drift rate of less than 6 degrees an hour, exclusive of earth's rate. Drift rate during vibration up to 2,000 cycles per second at 10 *g* is less than ±30 degrees per hour.

(*Continued on page 54A*)

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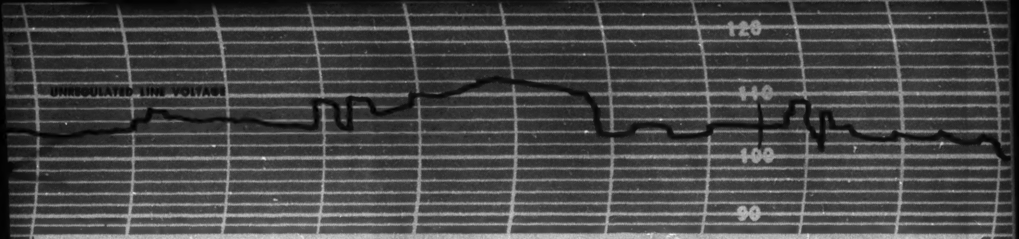
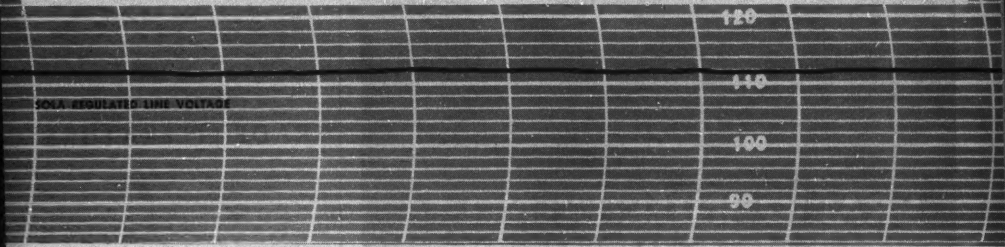
1955



TYPICAL RECORDING FROM A LINE VOLTAGE VARIATION SURVEY: The chart at the top is representative of the average line voltage condition found in a comprehensive survey of commercial and industrial establishments. A tracing at the same point made at another time might show entirely different conditions, since periods of stable voltage are often followed by periods of violent transient fluctuations and/or large, gradual swings. The bottom chart, recorded at the same time, shows the output voltage of a Sola Constant Voltage Transformer fed from this line.



End Fluctuating Line Voltage Handicap to Reliable Product Performance

Where line voltage fluctuations impair the performance of voltage-sensitive electronic equipment, Sola Constant Voltage Power Transformers often provide a simple, economical solution. Stock or custom designed units are available.

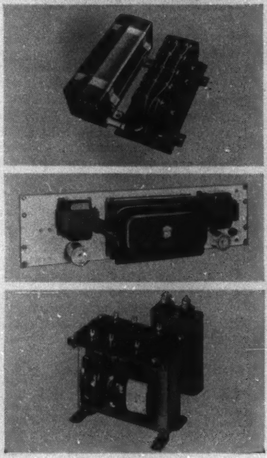
The Sola regulator has no moving parts and requires no manual adjustment or maintenance. Operation is automatic with response time 1.5 cycles or less. Regulates as close as ±1% with line voltage variations as great as 30%.

To meet special load requirements or service conditions, units can be custom-designed for production quantity orders. Variations available for special-order work include:

- *Capacity ranges from a fraction of a va to 30kva*
- *Wide variety of voltage inputs and outputs*
- *Frequencies other than 60 cycles*
- *Provisions for wide ambient temperature ranges*
- *Structural features for installation as a component*
- *Premium mechanical features for military service and other special duty*

The cost of Sola voltage regulation may be far less than you anticipate for two reasons: 1) installation of a Sola unit eliminates the need for the conventional non-regulating power supply transformer and any regulating components which you may currently use . . . 2) your requirements may be satisfied by a stock unit or custom design already on file. A Sola sales engineer is always available to discuss your voltage regulation requirements with you.

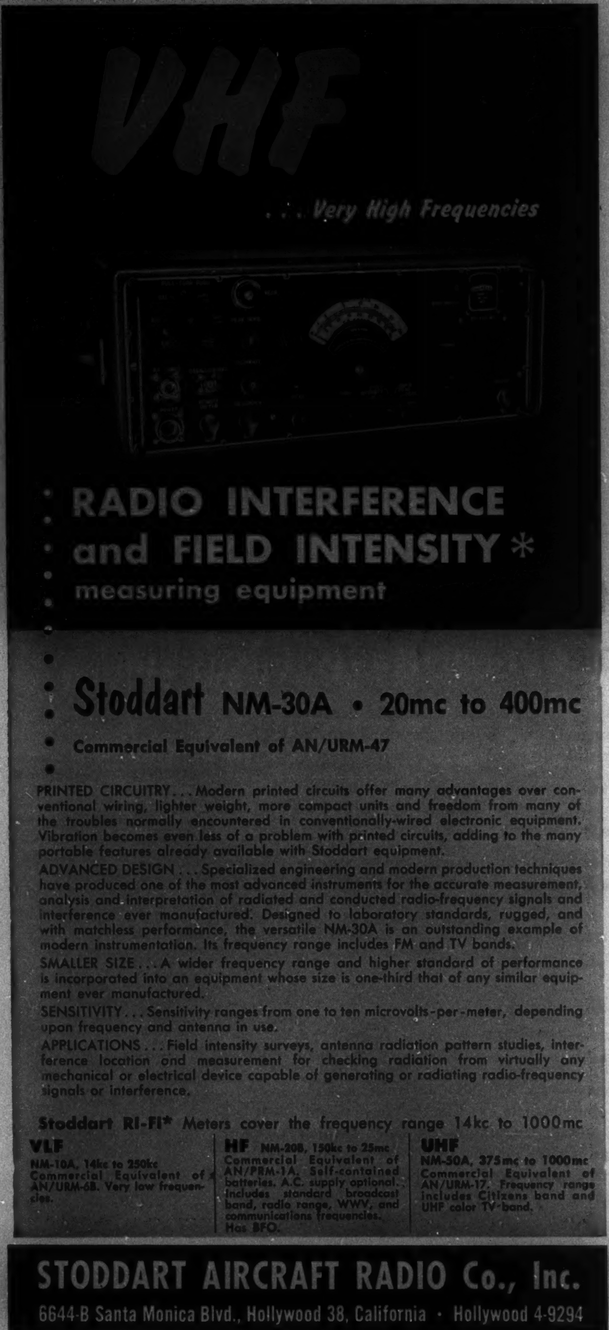
TYPICAL CUSTOM-DESIGNED
SOLA POWER TRANSFORMERS



SOLA *Constant Voltage* **TRANSFORMERS**

Write for Bulletin 5 E-CVES for facts on the complete line of Sola Constant Voltage Power Transformers.

CONSTANT VOLTAGE TRANSFORMERS for Regulation of Electronic and Electrical Equipment • **LIGHTING TRANSFORMERS** for All Types of Fluorescent and Mercury Vapor Lamps. • **SOLA ELECTRIC CO., 4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414** • *BOSTON:* 272 Centre Street, Newton 58, Massachusetts • *NEW YORK 35:* 103 East 125th Street • *LOS ANGELES 26:* 2025 Sunset Boulevard • *PHILADELPHIA:* Commercial Trust Building • *CLEVELAND 15:* 1836 Euclid Avenue • *KANSAS CITY 2, MISSOURI:* 406 West 34th Street • *TORONTO 9, ONTARIO:* 617 Runnymede Road
Representatives in Other *Principal Cities*


VHF

. . . Very High Frequencies

RADIO INTERFERENCE
and FIELD INTENSITY*
measuring equipment

Stoddart NM-30A • 20mc to 400mc

Commercial Equivalent of AN/URM-47

PRINTED CIRCUITRY . . . Modern printed circuits offer many advantages over conventional wiring, lighter weight, more compact units and freedom from many of the troubles normally encountered in conventionally-wired electronic equipment. Vibration becomes even less of a problem with printed circuits, adding to the many portable features already available with Stoddart equipment.

ADVANCED DESIGN . . . Specialized engineering and modern production techniques have produced one of the most advanced instruments for the accurate measurement, analysis and interpretation of radiated and conducted radio-frequency signals and interference ever manufactured. Designed to laboratory standards, rugged, and with matchless performance, the versatile NM-30A is an outstanding example of modern instrumentation. Its frequency range includes FM and TV bands.

SMALLER SIZE . . . A wider frequency range and higher standard of performance is incorporated into an equipment whose size is one-third that of any similar equipment ever manufactured.

SENSITIVITY . . . Sensitivity ranges from one to ten microvolts-per-meter, depending upon frequency and antenna in use.

APPLICATIONS . . . Field intensity surveys, antenna radiation pattern studies, interference location and measurement for checking radiation from virtually any mechanical or electrical device capable of generating or radiating radio-frequency signals or interference.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-6B. Very low frequencies.

HF NM-20B, 150kc to 25mc
Commercial Equivalent of AN/PRM-1A. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies. Has BFO.

UHF
NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17. Frequency range includes Citizens band and UHF color TV-band.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California • Hollywood 4-9294

(*Continued from page 42A*)

Dual-Grating Spectrograph. A new spectrograph which achieves a high degree of speed and versatility through the use of two gratings has been announced by the Bausch and Lomb Optical Company, Rochester, N. Y. Called a Dual-Grating Spectrograph, the instrument is designed to meet the increasing demands of atom-age spectrography. The instrument is described in catalogue *D-272*, available from Bausch and Lomb on request. The instrument will photograph complex spectra found in new metals and materials such as high-temperature alloys, uranium products, and rare earths. The use of two gratings in the new spectrograph provides two different spectral ranges in a single exposure on a single plate, or on two different plates.

TRADE LITERATURE

Servo-Tek Catalogue. Servo-Tek has announced the publication of their catalogue number *41*. This 36-page catalogue lists new servo motors, motor tachometers, and a new line of special transformers. Copies may be obtained from Servo-Tek Products Company, Inc., 1086 Goffle Road, Hawthorne, N. J.

Supplies and Accessories Catalogue. Air Reduction is offering a 36-page catalogue covering their line of arc welding oxyacetylene welding supplies and accessories. For a copy of this catalogue, *ACS 848*, write to Air Reduction Sales Company, 60 East 42d Street, New York 17, N. Y.

Design Data Book. Armco Steel Corporation has announced a new design data book on nine grades of silicon steel entitled "Armco Hot Rolled Electrical Steels." The 88-page book includes curves showing various magnetic properties for a very wide range of flux densities. Magnetic properties of silicon steel made by the Di-Max process are shown. A copy may be obtained by requesting it on company letterhead. Address: Product Information Service, Armco Steel Corporation, Middletown, Ohio.

Motor Control. Publication of a catalogue for electric motor controls has been announced by Furnas Electric Company. This pocket edition contains 46 pages of motor control photographs, specifications, and prices. It is designed as a convenient ready reference for magnetic starters and contactors, push buttons, combination starters, drum controllers, master, food, limit, and pressure switches. Copies of booklet number *5411* are available from Furnas Electric Company, 1063 McKee Street, Batavia, Ill.

Electrical Insulating Materials. A revised and enlarged 32-page catalogue that has descriptive information on electrical

(*Continued on page 58A*)

UPTEGRAFF

OVERHEAD TYPE UD TRANSFORMERS

for power distribution

WINDINGS

Long life is assured by the generous use of high rag-content fullerboard insulation, tied-in turns to meet short circuit forces and heat-reactive insulating varnishes.

BUSHINGS

Securely clamped internally, with generous gasket area to prevent failure of seals. High-voltage bushings (under 15 KV) have spring-loaded contacts; low-voltage have tinned contacts; both for either copper or aluminum conductors.

CORE

Made from high-grade oriented-type steel. Has low exciting current and low noise level, and remains permanently tight to insure consistent, quiet performance.

TANKS

All parts arc welded. Shot blasting assures adhesion of primer and finish coats of durable transformer paint. Rolled flange on cover permits high-pressure uniform gasket seal.

SIZES AND RATINGS

Type UD Transformers are built in sizes from 3 KVA to 100 KVA with ratings up to 15 KV.

TAP CHANGERS

Uptegraff designs feature accessibility, legibility, short-circuit capacity, non-deformable mountings, 360° rotation stops and exceptionally high insulation strength.

Write for free copy of new bulletin that details characteristics and other pertinent data.

UPTEGRAFF
TRANSFORMERS

R. E. UPTEGRAFF
MANUFACTURING CO.
Scottdale, Pennsylvania

R. E. Uptegraff Manufacturing Co.
Scottdale, Pa.

NAME__________
ADDRESS__________
CITY__________ STATE_____
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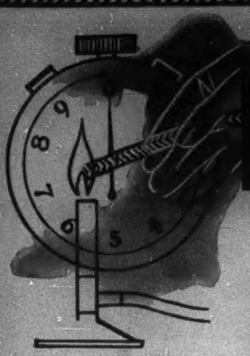


SWITCHBOARD
AVB — TA — SHFS
CABLE and WIRE

for operating temperatures up to 194°F or 90°C; 600V.

Tinned copper conductor, solid or stranded, taped in varnished cambric or extruded in polyvinyl, then felted with carded asbestos; finished in durable cotton braid and flame-retarding paint.—After all this, it's ready for both Underwriters' bunsen-burner and Navy spark-gap tests—and for *years* of fixed or flexing service ahead!

TRY to flame it!

Write for stock-catalog, or about your special requirements.

CONTINENTAL WIRE CORPORATION

Heat- and Moisture-Resistant Wires, Cables and Cords

PLANTS at YORK, PENNA.
and WALLINGFORD, CONN.

Serving 600 to 5000 Volts,
Sizes 18 AWG to 2,000,000 CM
SALES: Box 363, DEPT. MCE
WALLINGFORD, CONN.
(Phone COlony 9-7718)

TYPE F2 CARRIER-TELEGRAPH SYSTEM

Provides up to 40 teletype circuits on a telephone channel.

This compact, economical, high-grade, long-haul, main-line voice-frequency carrier-telegraph system is available in two channel spacings. The type F2A system, employing 120-cycle spacing between channels, provides up to 40 channels in the band of 300 to 4980 cycles. The type F2B system, employing 170-cycle spacing, provides up to 28 channels in the band of 255 to 4835 cycles. Up to 15 channels with oscillators, relay test and metering facilities, jacks and bay terminals will mount on a single 8-ft. bay. A channel-terminal panel containing send and receive circuits for one channel requires only 5¼″ and four channel oscillators only 1¾″ of space on a 19″ rack. A highly-developed level-compensation circuit provides practically undistorted signal reception over a wide variation of line net loss. Standard loop options are half- and full-duplex, battery normal and reversed.

New and exclusive techniques in the design and manufacture of filters and oscillator networks provide a higher degree of frequency stability than has previously been possible, with resultant reduction in signal distortion. This equipment is in current production, and early deliveries can be made of complete systems or of single panels.

Typical 6-channel packaged terminal of type F2 equipment. This is the type AN/FCC-12 (Channels 1-6) or AN/FCC-13 (Channels 7-12) Telegraph Terminal, as manufactured for the U.S. Army Signal Corps. It is complete with regulated-tube rectifiers for plate and bias supply, and positive and negative telegraph loop-current supplies, jack field, relay test panel, monitor circuits, fuses, spares, etc. The equipment is moisture- and fungus-proofed, and meets military standards where applicable. Up to four cabinets may be used together, to provide a completely self-contained 24-channel terminal.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY STREET, MONTREAL 3, CANADA
Telephone: UNiversity 6-6887
Cable Address: Radenpro, Montreal
MANUFACTURERS OF CARRIER-TELEGRAPH, CARRIER-TELEPHONE AND BROAD-BAND RADIO SYSTEMS

(*Continued from page 54A*)

insulating materials is available from Insulation Manufacturers Corporation. For a free copy of the catalogue write to Publications Department, Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill.

Switches Catalogue. Micro Switch, Freeport, Ill., a Division of Minneapolis-Honeywell Regulator Company, has released a new 28-page catalogue, number *62*, on precision snap-action basic switches. Over 400 listings of basic switches, auxiliary actuators, and terminal enclosures are covered. Complete with photographs, dimensioned drawings, terminal variations, electrical ratings, and technical information, catalogue *62* is intended to aid the design engineer in the proper selection of switches for his particular requirements.

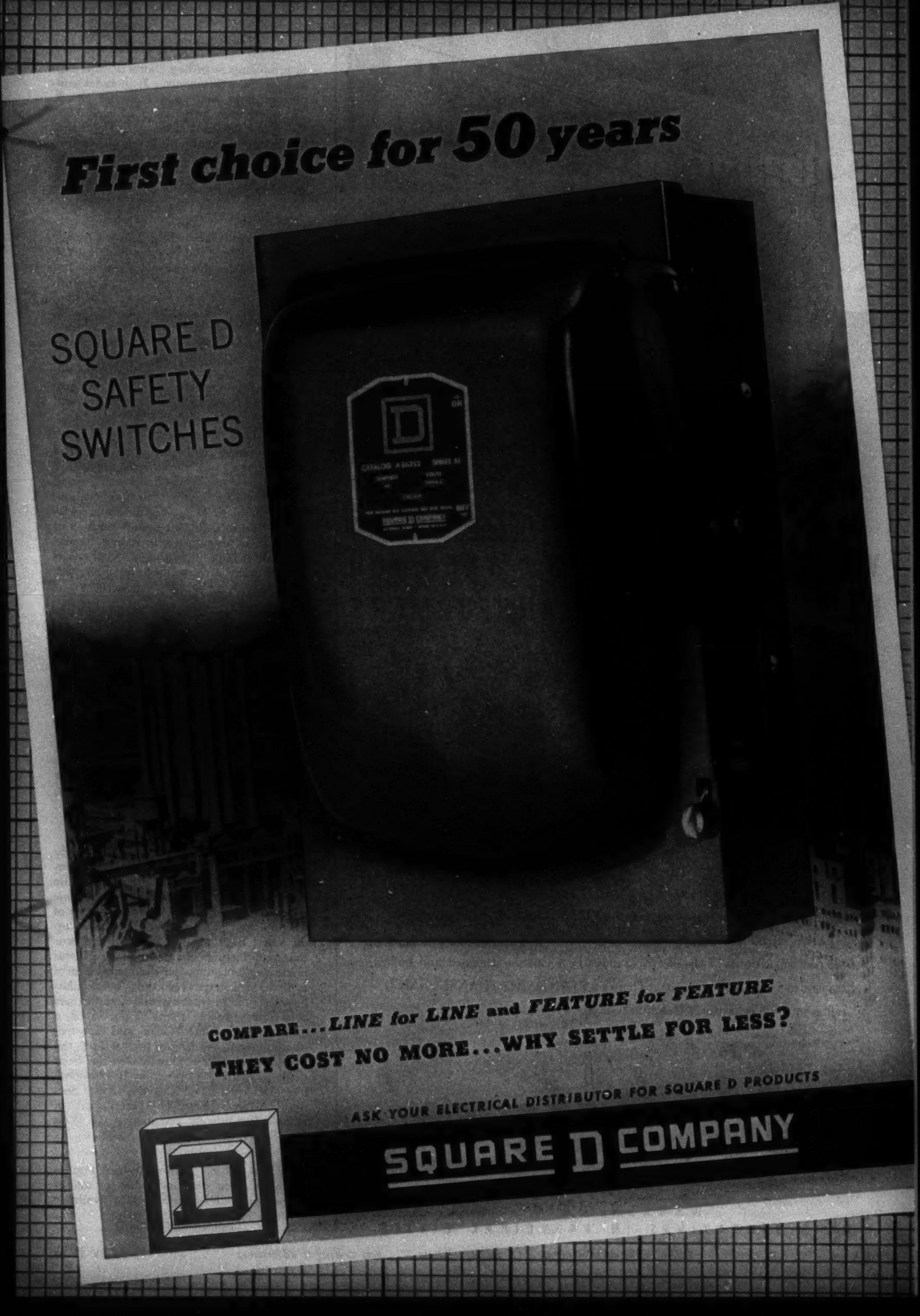
Microwave-Radio System. A complete description of 2,000-mc microwave-radio systems for a variety of applications is given in a new 8-page booklet available from the Westinghouse Electric Corporation. Features of type-*FR* microwave radio and type-*FJ* multiplexing equipment and their importance to the over-all system are discussed. For a copy of this booklet, *B-6393*, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

General Radio Bulletins. Three new bulletins describing General Radio Company's recently developed or improved instruments has been announced. Automatic line-voltage regulators, type *1570-A*, Variac (registered trade-mark) motor speed controls, and type *1862-B* megohmmeter, are fully described in these bulletins. The type *1862-B* megohmmeter provides two test voltages, 50 and 500 volts, for the measurement of high resistances. Especially useful for checking insulation resistance on all types of equipment, the megohmmeter will measure up to 2,000,000 megohms. Copies of these publications are available on request from General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass.

Tube Booklet. Availability of a new 40-page designer's booklet, *ETD-985*, on cathode-ray tubes for industrial and military applications has been announced by the General Electric tube department. The booklet provides data on 24 standard General Electric tube types, and describes the company's engineering and production facilities available to meet specialized customer requirements. Technical information in the booklet includes tube essential characteristics, gun design factors, and a description of standard phosphors covering color, persistence, and spectral response. The booklet may be obtained from the General Electric Tube Department, Schenectady 5, N. Y.

Technical Charts Brochure. Technical Charts, Inc., of Buffalo, N. Y., offers a new 12-page catalogue outlining their services

(*Continued on page 60A*)



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COMPARE...*LINE* for *LINE* and *FEATURE* for *FEATURE*

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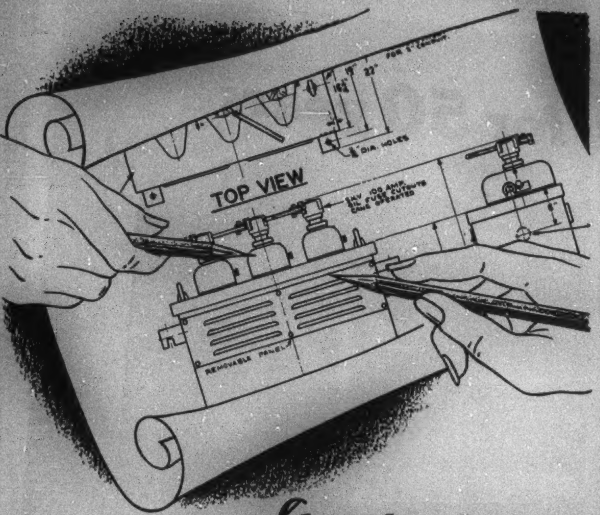
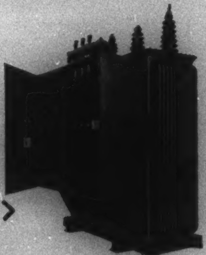


Standard WORKS WITH YOUR ENGINEERS WHEN YOU NEED Special TRANSFORMERS

25 KVA Dry Type Load Center Transformer with primary oil-filled fused cut-outs.



1000 KVA Special Unit Sub-Station — 66,000 to 2400 volts.

Working with you, STANDARD engineers can greatly assist in planning special transformer installations for a specific need in your plant. Experienced STANDARD engineers have an excellent understanding of the particular needs of the electrical industry. Custom-designed and built transformers are their specialty. There's a STANDARD TRANSFORMER representative near you. Call him today!

The Standard

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REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 58A*)

in producing recording charts for standard and special instruments. It includes samples of both dial- and roll-type charts. The method of production of over 8,000 different standard charts is outlined. Technical information is given on requirements for special charts. Copies may be obtained by writing Technical Charts, Inc., 189 Van Rensselaer Street, Buffalo 10, N. Y.

Oscillographic Recording. A new 6-page folder describing the versatile Sanborn *150* series oscillographic recording systems and components is available on request from Sanborn Company, Industrial Division, 195 Massachusetts Avenue, Cambridge 39, Mass. The folder contains technical data and specifications on 2- and 4-channel systems, six available plug-in preamplifiers, single-channel recorder, 4-channel system for use with analogue computers, and individual portable cases for recorders and amplifier-power supply units.

Torquemeters Bulletin. Baldwin *SR-4* torquemeters and their applications are described in 12-page bulletin *4308*, issued by Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa. Eight torque pick-ups, 0–100 to 0–30,000 inch-pounds, and five types of instruments, including manual null balancing and automatic indicators and recorders, are described and illustrated.

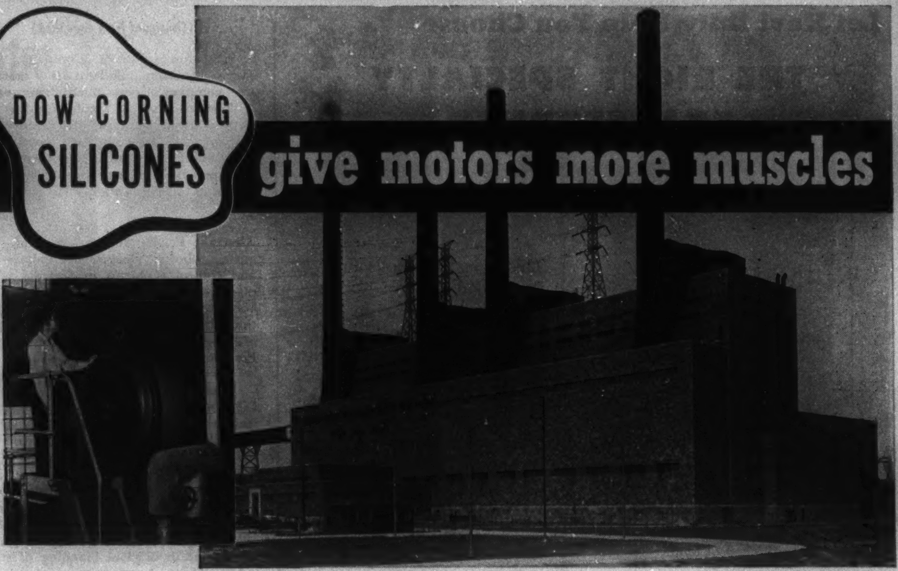
Information on Titanium Tubing. Tubing of titanium, the promising and comparatively new metal, is described in bulletin *43*, recently published by Superior Tube Company, Norristown, Pa. The 8-page bulletin "Titanium, New Member of the Family of Metals," presents the most up-to-date information on the fabrication of unalloyed titanium tubing. Subjects covered include heat treating, pickling, welding, brazing, and machining. Copies of this publication may be obtained by addressing requests to Superior Tube Company, 1517 Germantown Pike, Norristown, Pa.

Color and Spectrophotometry. A new service that eliminates human error from specifications of colors for industry and the government has been established at Armour Research Foundation of Illinois Institute of Technology. The color service was set up on a test basis to aid industrial concerns that manufacture colored products. It was made available through the acquisition of a General Electric recording spectrophotometer, an instrument that standardizes colors by reducing them to curves on a graph. A booklet, "Color and Spectrophotometry," describing the uses of the Foundation's spectrophotometer, has been made available. Copies may be obtained, free of charge, by writing the Optics Section, Armour Research Foundation of Illinois Institute of Technology, 10 West 35th Street, Chicago 16, Ill.

Wire and Cable. A new illustrated bulletin on shielded wire and cable for microphone and sound systems is now available

(*Continued on page 64A*)

DOW CORNING SILICONES give motors more muscles



Power company specifies silicone insulated fan motors because they cost less to buy . . . less to install . . . less to operate.

This 1000 hp, 1190 rpm forced draft fan motor, for example, has been operating for over four years in ambient temperatures up to 54 C at the Philip Sporn plant on the American Gas & Electric System.

Starting against cold air as many as 4 times a day, it is overloaded by 30% to bring its total rise to 120 C with a total output of more than 1300 hp. Built by the Elliot Company, the coils of this particular motor are wrapped with Silastic R Tape to give maximum vibration resistance.

Because it is smaller and easier to install than an equivalent 1500 hp conventional motor, it costs less to buy. And because it can safely carry the high initial loads, it operates at maximum efficiency with no power factor correction under normal loads.

That's why there are 40 Class H fan motors rated from 1000 hp to 1500 hp currently in service on the American Gas & Electric System with 20 more on order from several leading manufacturers. These experiences and purchases confirm the findings of other progressive power companies.

And what better proof could there be of the fact that Class H insulation made with Dow Corning silicones, saves money and increases the life, reliability and capacity of electric machines?

This experience also confirms the conclusions of another eastern utility, the Consolidated Edison Company who have long been buying Class H for major motors. For them, and for you, silicone insulation means more power and greater dependability — at less cost.

You can also reduce to a minimum motor outages due to bearing failure by using Dow Corning 44 Grease

In open and single shielded bearings designed for high temperature operation, Dow Corning 44 has 8 to 10 times the life expectancy of conventional greases. It gives life-time lubrication in permanently sealed bearings.

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☐ More performance data on Class H
☐ List of Class H rewind shops
☐ List of Class H Motor and ☐ Class H Transformer Manufacturers

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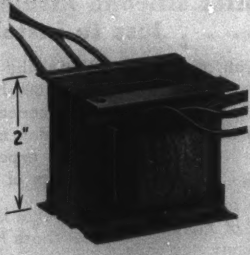
Let Hevi Duty Help You Choose

THE RIGHT SPECIALTY TRANSFORMER

This autotransformer is used for reduced-voltage starting of synchronous and induction motors. 50, 65 and 80 percent taps are normally provided. Terminals may be mounted on the coil or leads.

This is just a small sample of the broad line of specialty transformers built by Hevi Duty Electric Company. They are available in all sizes with any desired primary or secondary voltages or frequencies. All are designed to meet or exceed NEMA standards.

Type SICB, 150 VA, 230/460-115 volts, enclosed style with a built-in thermal circuit breaker for overload protection. This compact unit saves valuable panel space.

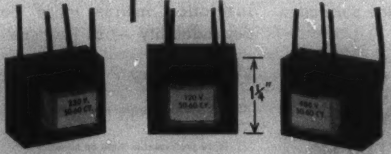


Type SIO, 10 VA, primary 110/220 volts

CONTROL WINDING
Secondary 230 volts, .032 amps, 7.4 VA

FILAMENT WINDING
Secondary 6.3 volts, .3 amps, 1.9 VA

Low-voltage pilot light transformers up to 600 V primary.



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HEVI DUTY ELECTRIC COMPANY
MILWAUKEE 1, WISCONSIN
Heat Treating Furnaces . . . electric exclusively
Dry Type Transformers *Constant Current Regulators*

(*Continued from page 60A*)

from Whitney Blake Company, New Haven 14, Conn. Bulletin *SW-1* describes the company's new microphone cables with semiconducting textile shield as well as the conventional types with braided copper shield. The company's new speech input and sound system cables with semirigid polyvinyl chloride insulation are included in this publication.

Thermal Power Stations Booklet. Engineers who are dealing with supervision and control problems in thermal power plants will be interested in a new 32-page booklet which gives detailed information on this subject. Copies may be obtained free of charge from Hartmann and Braun A. G., Frankfort/Main, Falkstr. 5, Germany.

Lighting Equipment. The ten catalogue sections of lighting equipment, which have been issued by The F. W. Wakefield Brass Company, Vermilion, Ohio, have been designed for brevity in copy, and simplicity in drawing and tables. In addition to the increased availability of modular materials and equipment, a major development of the 1950's has been the recognition of lighting equipment in original planning of structures. These have bearing upon the generally "architectural" flavor of the catalogues, which does not detract from the factual material presented in this series.

Transistor Design Sheets. A 10-page set of design sheets describing transistors and their application is available from the Westinghouse Electric Corporation. Design data are given for three new Reliatron (registered trade-mark) transistors, P-N-P junction types *2N54*, *2N55*, and *2N56*. General semiconductor theory is discussed, and equivalent circuits and equations are derived for grounded-base, grounded-emitter, and grounded-collector connections. Circuits for a phonograph preamplifier and an audio oscillator are shown to illustrate typical transistor applications. For a set of transistor design sheets, write Westinghouse Electronic Tube Division, Commercial Engineering Department, P. O. Box 285, Elmira, N. Y.

Film Strip on Transformer Protection. A new 35-mm color sound film strip, "Kilowatt Insurance," which explains the basic theories of transformer protection against lightning, short circuits, and overloads, has been released by Allis-Chalmers Manufacturing Company. The film runs about 20 minutes, and diagrams the various methods of protecting transformers and interconnecting devices. Internal and external views of distribution transformers point out design characteristics to meet service conditions. Prints of "Kilowatt Insurance" for showing before engineering and utility training groups are available on request from the motion picture section, Allis-Chalmers Manufacturing Company, General Machinery Division, Milwaukee 1, Wis.

(*Continued on page 68A*)

After TWO years of field-testing, here's the

NEW IMPROVED TIREX CORD

- *It's more flexible than ever before!*
- *It has greater pliability when cold!*
- *It's much easier and faster to machine-strip!*

New TIREX CORD retains its Selenium Neoprene Armor for added toughness.

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New TIREX CORD is still cured in lead to make it smoother, denser and more uniform.

The New TIREX is the most supple, limber TIREX Cord ever made!

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Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

Inquiries invited concerning pads or turrets with different connector styles

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SINGLE "IN-THE-LINE" ATTENUATOR PADS and 50 ohm COAXIAL TERMINATION

(*Continued from page 64A*)

Better Transformers. To instill in its employees a desire to turn out a better product, and to provide practical help to that end, Allis-Chalmers' Pittsburgh Works recently carried in its employee magazine, *A-C Spotlight*, a series of articles entitled, "What Can I Do to Help Make Better Transformers?" Authored by J. B. Hodtum, manager of central station engineering at Pittsburgh Works, the articles were written to give employees a better understanding of transformer theory. The articles have been collected into bulletin form for those concerned with the application of transformers, and fundamentals of transformer design and construction. Title of the 20-page booklet is "The ABC's of Transformer Design and Application."

Booklet on Air-Borne Electric Power. A 31-page booklet on air-borne electric power is available from the Westinghouse Electric Corporation. The booklet emphasizes, through illustrations and text material, the facilities available for developing, producing, and testing aircraft electric system and components. The booklet covers such subjects as systems engineering, development, environmental, mechanical, and load tests, and manufacturing facilities. Many components of air-borne electric systems are also discussed. For a copy of booklet *B-6392*, write to Westinghouse Electric Corporation, Post Office Box 2099, Pittsburgh 30, Pa.

Control Systems for Nuclear Reactors. Leeds and Northrup Company offers complete "package" control systems for any type of research or power reactor. The company reports that package systems, including design, instrumentation, and fabrication of the complete control, provides the qualities necessary for accurate control without elaborate customizing. For further information, request folder *ND46-70-700* (*1*), "Control Systems for Nuclear Reactors," from Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.

Franklin Institute Booklets. The Franklin Institute Laboratories for Research and Development is stressing and expanding its section on engineering psychology. Experimental psychology, engineering analysis, probability, and statistics, are representative disciplines the Institute used in its engineering work. In order to acquaint businessmen with this and other services of the Franklin Institute, a series of booklets is being prepared. The facilities of the Institute will be illustrated, problems it is equipped to handle will be outlined, and projects now underway or already completed will be discussed. The first brochure, "Engineering Psychology," is available as of April 1. Others in the series will describe the Institute's activities in product research and development, automation, lubrication, and bearings, etc. Those wishing to receive these booklets should write to the Franklin Institute and ask to be put on their mailing list.